COOKING WITH PLANTS IN ANCIENT EUROPE AND BEYOND

Interdisciplinary approaches to the archaeology of plant foods

SOULTANA MARIA VALAMOTI, ANASTASIA DIMOULA
AND MARIA NTINOU (EDS)

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The processing of plant ingredients for food has characterized the genus *Homo*, with the grinding, fermentation and cooking of plant ingredients improving their nutrient intake and leading to increases in brain-size, improved population sustainability, and cultural development (e.g. Stahl 1989; Wrangham 2009). Plants have fed human societies since Palaeolithic times and their central position has been increasingly highlighted over the last decade through sophisticated analytical methods extracting pollen and starches from Neanderthal teeth, or phytoliths and starches from the surface of Palaeolithic tools. Barbara Bender's inversion of the hunter-gatherer stereotype into gatherer-hunter back in 1978, was very perceptive though little-noticed by researchers of prehistoric communities of the Old World. Four decades later, the shift in emphasis and discourse on prehistoric food is clear: wild plants and plant foods in general appear to have been the staff of life, sustaining human populations since the Palaeolithic era (e.g. Aranguren et al 2007; Carrión et al 2018; Hardy 2018). It seems that the stereotype of the male hunter and his team bringing meat to the hearth is giving way to plant foods, including medicines, being harvested from the wild and consumed by the pre-agricultural human communities that inhabited different regions of the Earth. The transformation of plants into food was perhaps largely associated with women, assuming that the available ethnographic evidence can, to some extent, be extrapolated to the prehistoric past.

The preparation and consumption of food is closely connected to cultural, social and economic aspects of human societies, of both past and present alike. Food preparation techniques, the selection of ingredients and their transformation into meals, as well as the etiquette of consumption, correspond to complex choices resulting from the interplay of environmental and cultural factors: available ingredients, technologies of transformation, worldviews, cultural perceptions of food, taste, and food taboos (e.g. Levi-Strauss 1962; Douglas 1966; Simoons 1998). Major changes in human societies in prehistoric times such as the shift to permanent habitation, storage, social differentiation and the shaping of trans-egalitarian societies involved the cultivation and domestication of plants, along with production of alcohol and luxury foods. Archaeology can make a major contribution to revealing aspects of past dietary habits and food preparation and consumption practices. Food studies are increasingly acquiring a significant position in archaeological inquiry, building upon what Sherratt (1991) had very perceptively argued for, more than 30 years ago, that *people do not eat species, they eat meals*. Conferences, papers, and books have addressed food preparation and consumption, focusing on luxury foods (van der Veen 2003), particular consumption practices like feasting on meat and alcohol (Miracle and

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Milner 2002; Wright 2004; Jones 2007), and the variable social, economic and symbolic dimensions of food across the globe (Gosden and Hather 1999). Research projects have investigated food globalization in prehistory (ERC funded FOGLIP project), the Early Neolithic cuisines of the north Balkans (FoodCultures) and the consumption of particular foods (e.g. milk, EU-funded LeCHE and NeoMILK projects). At the same time, edited volumes on the subject of food have embraced a wide array of methods, approaches and case studies regarding various regions and time periods, including methods and analytical tools from the hard sciences like chemical residue and isotopic analysis (e.g. Parker-Pearson 2003; Mee and Renard 2007; Tzedakis et al 2008; Voutsaki and Valamoti 2013). The last decade has witnessed a flux of research articles on various aspects of plant foods researched through a wide array of scientific methods (e.g. Garnier and Valamoti 2016; Cubas et al 2020; Drieu et al 2021; Dunne et al 2022) while books have been published on the archaeology of food (e.g. Hastorf 2016; Fritz 2019; Twiss 2019; Cutright 2021).

The importance of plant foods for past societies has been underlined through recent archaeological discourse with special emphasis being placed on cereal staples, luxury foods and diet enhancers such as wine and oil, condiments and spices or special plants like chili peppers, cocoa or opium poppy (e.g. Sherratt 1995; Hamilakis 1996; Hastorf 1998, 2016; van der Veen 2003; Fuller and Rowlands 2011). Prehistoric culinary and food consumption practices have been at the heart of discussions on the emergence of Bronze and Iron Age elites in prehistoric Europe (e.g. Renfrew 1972; Arnold 1999; Wright 2004), with regards to wine and oil in particular, relating power appropriation and access to certain types of plant foods and associated processing technologies. Species selection and their transformation into meals involves the interaction of natural vegetation and human culture, whereby the former is shaped, named and incorporated into each society's belief system, transmuted into daily and life experiences, collective memory and identity. Food preparation and consumption form arenas where social roles are learned and power relations forged, negotiated and renewed (e.g. Dietler and Hayden 2001; Jones 2007). Yet, ancient plant foods, despite their major dietary and cultural role, have for a long time remained, underexplored in terms of individual recipes and the processes underlying the preparation of specific prehistoric foods. They are little discussed regarding their contribution to social cohesion and differentiation through their daily, communal or special contexts of consumption, as well as their role in elite emergence and cultural transformation over time. This has changed in recent years. Research projects have explored plants, as major dietary contributors to past societies, with the support of the EU, e.g. Plants and Culture, the ESF-funded project EARTH (Chevalier et al 2014) and the ERC-funded AGRICURB project, addressing aspects such as plant symbolism, crop processing and cultivation practices (Styring et al 2017; Diffey et al 2020). The role of wild plants as food has been highlighted in collective volumes (e.g. Hardy and Kubiak-Martens 2016). Plant food preparation has been investigated through case studies from across the globe (e.g. Capparelli et al 2011; Arranz-Otaegui 2021) or in an attempt to investigate plants and associated tools (Anderson et al 2013). Yet, the culinary transformation of plants has not been the focus of a systematic enquiry and even less so as regards more integrated approaches combining ingredients and food transformation technologies (cf. Mesnil and Fechner 2002). Moreover, the culinary transformation of plants into food has not been investigated on a regional and temporal scale that would allow for culinary trends and their changes over time to be observed in a coherent way. As a result, the dynamic role of the culinary transformation of plant ingredients in shaping social and cultural identity in prehistory remains little explored and comprehended. Ongoing research by various interdisciplinary groups, however, is drastically changing the picture (e.g. Valamoti et al 2017; Spengler 2019; Scott et al 2021; Vieugué and Mazzucco 2021). It is very hopeful that such approaches are expanded beyond prehistoric times to more recent historic periods (Chantran and Cagnato 2021).

The plant food ingredients that have been available over the course of prehistory and history have had significant impacts on cultural transformation and change, with cultural contacts introducing new species, ingredients and cooking techniques through complex interactions of individuals or groups of people (e.g. Spengler et al 2014; Kreuz and Friedrich 2014; Valamoti 2016). Alongside these changes, existing plants were transformed into new species or varieties, enriching the available ingredients, and the quantity available of them along with particular sensory qualities. At the same time new yeasts and bacteria also developed that resulted in a yet greater wealth of nutrient availability and variety in taste and culinary sophistication (e.g. Papadimitriou et al 2015). Cultural and social distinctions built on plant foods can be gleaned from ancient texts about daily and special foods, the cooked and the raw, the wild and the tamed, the food of the Greeks and the others, and so on (Vidal-Naquet 1983). The contribution of plant foods to social classificatory systems, rites of passage or other special occasions is also apparent in the ethnographic literature (e.g. Levi-Strauss 1962; Simoons 1998). How far back can we trace such distinctions? For periods lacking textual evidence this is indeed an ambitious goal and a challenge, yet, the development of sophisticated analytical tools that allow the examining of teeth, tools, and ceramic vessels for tiny traces of food are changing the picture drastically. When archaeological evidence is integrated with ancient texts it offers exciting narratives through the investigation of what certain ancient authors thought about food and what people actually did with plant food ingredients (e.g. Valamoti et al 2022).

Over recent years the books and edited volumes that have appeared in the literature, have showcased the importance of plants for covering the various needs of past human societies, with food being a central one. These studies explore the journey of plant resources procured from the wilderness and fields all the way to the "rubbish" pit or whatever context became associated with the completion of their biography. The need for an integrated study that would examine actual plant-food remains, together with their available food technologies and contexts of transformation into food, led to the birth of the idea of the PlantCult project, funded by the European Research Council (ERC) as part of a Consolidator Grant Scheme (GA 682529). The aim of the project was "to explore prehistoric cuisines of Europe, in particular their plant ingredients and their transformation into meals"; the project brought "together plant remains, food remains, cooking pots and installations, grinding equipment and cooking processes, from the Aegean to Central Europe, in an attempt to decipher culinary practices and identities from the first farming communities to the first cities that emerged at the end of the Iron Age", an approach "enriched by considering, together with the archaeological record, a wealth of ethnographic observations, experimental replication and ancient texts" (http://plantcult.web.auth.gr/en/, Valamoti et al 2017).

To this end, key sites from a large part of Europe were investigated, ranging from the Aegean to Central Europe. In the context of PlantCult actual remains of plant foods from Greece, Bulgaria and Central Europe have been analysed and methods to interpret them have been investigated and published (Heiss et al 2017; Heiss et al 2019; Hristova et al 2019; Valamoti et al 2019; Berihuete-Azorin et al 2020; Heiss et al 2020). Some have even featured in the press with catchy titles about "mini bagels" (https://www.nature.com/articles/d41586-019-01736-z) or "the oldest beer" (https://thesciencebreaker.org/breaks/evolution-behaviour/the-oldest-beer-in-central-europe-take-it-with-a-pinch-of-malt). This volume attempts to place PlantCult's scientific output in a broader context, both geographically and temporally, transcending the project's spatiotemporal limits, thus bringing its finds to a fruitful dialogue with archaeologists working on similar topics to those explored in the project, in different parts of the world and on various periods. Aspects of ancient plant food preparation are examined through the lens of archaeological remains in the collection of papers featuring in the present volume. Archaeology, however, is not only important for understanding the past. Our work has repercussions for the present and the future, especially when it comes to plant foods, therefore the book also offers a collection of papers that present how modern societies have dealt with the plant foods of prehistoric times and how the past emerges in the present in conscious and intentional activities that have the potential to set new trends rooted millennia ago.

Our volume is titled "Cooking with Plants in Ancient Europe and Beyond" and comprises 30 scientific papers that examine ancient plant foods in different parts of the world, from a variety of perspectives, organized into three parts. The vast majority of contributions in this volume focus on plant food ingredients and actual foods that were consumed in the past (Chapters 1-15). A collection of papers (Chapters 16-24) discuss the transformation of plants into food from the perspective of processing equipment and cooking facilities such as grinding tools, pots and thermal installations. Six contributions at the end of the book (Chapters 25-30) weave a thread that connects modern plant foods to their prehistoric past.

The volume opens up with a PlantCult synthesis of archaeobotanical data from southeastern and central Europe in order to explore cereal and pulse food choices in the Neolithic (Chapter 1). Evidence from 21 sites in northern Greece, archived and analysed with ArboDat, form the core of the paper which places this evidence in the wider framework of discussions regarding the spread of agriculture from the Aegean to Central Europe, with special emphasis on food and identity. This is a joint effort with close PlantCult collaborator, Angela Kreuz, the founder of ArboDat (e.g. Kreuz and Schäfer 2002) and a large team of archaeobotany students at the Laboratory of Interdisciplinary Research in Archaeology at the Aristotle University of Thessaloniki (LIRA). From this broad picture of the Neolithic, the exploration of prehistoric plant foods continues with a key PlantCult site, Archondiko, studied in the context of Chryssa Petridou's PhD; with its rich inventory of cereal crops and actual plant food remains, the wide range of processed cereals in the form of fragments and lumps presents a stimulating incentive for considering alternative foods such as bulgur, *trachanas* or a starter for brewing beer and/or bread-making (Chapter 2). Continuing with PlantCult research results and joining forces with the Montpellier team, Vincent Bonhomme, Laurent Bouby and Sarah Ivorra, the next article offers a fresh and innovative methodological approach to the distinction of wild and domesticated grapevine; the paper builds on modern reference material and archaeological finds from Greece, the latter investigated by Clémence Pagnoux in the context of her PlantCult postdoctoral research and is enriched by material contributed by Susan Allen (Chapter 3). Continuing with prehistoric Greece, two studies concerning the Bronze Age offer integrative approaches to plant food ingredients. Maria Ntinou, Angleliki Karathanou and Clémence Pagnoux focus on charred plant macro-remains including wood charcoal from central mainland Greece as part of their postdoctoral and PhD PlantCult research; by integrating two categories of plant macro-remains the paper offers exciting insights into the diachronic inter-relationship between people and plants that grew both in managed patches of vegetation such as fields and pastures as well as wild vegetation from the 3rd to the end of the 2nd mill BC, especially in relation to olive and grapevine domestication and cultivation (Chapter 4). The contribution that follows has as its focus the southern Aegean and brings together archaeobotanical and textual evidence in an attempt to assess the role of cereal and pulse staples in Minoan and Mycenaean societies (Chapter 5). In their article, Paul Halstead, Amy Bogaard and Glynis Jones emphasize the complementary nature of, and underline the contradictions in, the narratives offered by the two lines of evidence, offering an integrative, fresh look and interesting insights as regards the identity of the cereal species potentially mentioned in Linear B texts.

Moving eastwards to Anatolia and the wider area of the East Mediterranean, two contributions allow insights into Neolithic and Late Bronze Age plant food ingredients and cooking transformation. In the paper, led by Ceren Kabukcu and co-authored by Eleni Asouti, Emma Percival, Ellen Grice and Necmi Karul, archaeobotanical evidence from late 7th – early 6th mill BC Aktopraklık in northwest Anatolia reveals a great variety in cereal, pulse and other plant food species, as well as a wealth of food mass remains that invite further investigations in the future (Chapter 6); this new evidence, together with recent food remains from Çatalhöyük (González-Carretero et al 2017), the Near East (Arranz-Otaegui 2021), India (Bates et al 2022) as well as the older seminal work by Delwen Samuel on Egyptian bread and beer remains (Samuel 1996a, 1996b, 1999) underline how timely the work undertaken by PlantCult has been (e.g. Heiss et al 2017; Heiss et al 2020; Valamoti et al 2021), especially in developing methodological tools for the archaeological identification of plant food remains and in highlighting the importance of studying similar remains that often remained neglected, and are grouped into broad categories such as "food crust" or "indeterminate mass". The work of Janine Fries-Knoblach and Philipp Stockhammer takes us on a journey through the different lines of evidence that reveal plant food ingredients which may have been consumed in the Eastern Mediterranean in the 2nd mill BC (Chapter 7). Organic residue analysis, archaeobotanical remains, and plant micro-remains are among the types of evidence the team from the FoodTransforms ERC project use to examine what individuals ate through analysis of surviving plant food ingredients trapped in human dental calculus; their work thus offers a complementary picture of past dietary practices through snapshots from what individuals ate during their lifetime. The potential identification of exotic plant foods that have not been detected in archaeobotanical plant macro-remains is a challenging and exciting aspect of the FoodTransforms research that may yield unexpected and fascinating results on exotic plant foods that may have reached the Eastern Mediterranean through contact networks with regions further to the East, including India and southeastern Asia. The volume's easternmost contribution indeed comes from the land of spices and flavours, India. The work of Jennifer Bates places the spotlight on the often-neglected plant remains that correspond to plant species that were not cereal or pulse staples but may have acted as diet enhancers (Chapter 8). Bates invites us to contemplate on the emic nature of taste and the limits of archaeobotanical reconstruction of past foodscapes.

Leaving the spicy foodscapes of the East, the volume's exploration of ancient plant foods heads northwards to Serbia and Central Europe. Dragana Filipović, Djurdja Obradović and Anne de Vareilles explore the plant food ingredients of Serbia, Kosovo and Bosnia and Herzegovina, from the Early Neolithic through to the end of the Bronze Age, offering a wealth of new information thanks to the systematic work of the dynamic group of archaeobotanists working in the region (Chapter 9). New plant food ingredients, brought by the early farming communities that spread from Greece northwards along the river valleys connecting the Aegean to Central Europe, formed the dietary basis upon which new introductions left their mark on the culinary landscape of the region with the later arrival of millet, *Lallemantia* and opium poppy. The chapter offers an impressive regional synthesis for the whole of the Neolithic and the Bronze Age for the first time, expanding to adjacent regions, too, a valuable contribution that provides the basis for a comprehensive synthesis for the whole of southeastern Europe in the near future. Moving northwards to Celtic Central Europe, Joshua Driscoll focuses on alcoholic drinks, beer in particular (Chapter 10). Through a series of experiments whereby he tests the shelf-life of beer in different containers, he attests against the widely held view that beer does not store well. His observations have a significant impact on our perceptions about the logistics of Celtic feasting relying on beer and offers a novel look at the discussion of wine and status among the Iron Age populations of Western Europe.

The exploration of prehistoric plant foods in Europe continues among its northern parts, away from the sunny shores of the Mediterranean to the Netherlands and the foods of the Neolithic communities of the Swifterband. Lucy Kubiak-Martens offers a very thorough consideration of plant food ingredients used as food by the community inhabiting Tiel Medel in the Middle Neolithic of the Netherlands (Chapter 11); her long involvement in prehistoric food research in the Netherlands and Egypt enables her to paint a vivid picture of food habits in regions that experienced this new way of life through new food ingredients much later than their Mediterranean counterparts. The paper touches upon an extremely interesting aspect of food, that of cuisine and identity, in the context of interactions between the former way of acquiring plant foods through gathering and the new way of life which added new ingredients brought from crop fields to the extant stock.

Moving westwards, the Iberian Peninsula offers us a rich account of prehistoric plant foods, starting from the Palaeolithic and the use of wild plant food resources, continuing with the first farmers of the Neolithic and those of the Bronze Age, finally reaching the Iron Age societies that experienced the influence of colonizers and trading networks which brought about important changes in the range of ingredients and how they were transformed into food. Ernestina Badal and Carmen Martínez Varea present the impressive archaeobotanical finds from four Palaeolithic sites in Spain that convincingly suggest the strategic harvesting and processing of pine nuts and other wild plants (Chapter 12). Their paper shows how plant foods were important among gatherer-hunter communities, lending further support to recent research on similar food sources during the Palaeolithic. Leonor Peña Chocarro and Guillem Pérez-Jordà bring together a large body of data from the Iberian Peninsula spanning from the 7th to the end of the 1st mill BC (Chapter 13). They highlight the main cereal and pulse crops of these periods and shed light on aspects of fruit harvesting and consumption, addressing the issue of the timing of the introduction of viticulture and oleiculture in the Western Mediterranean.

Meriel McLatchie takes us closer to our times, to Medieval Ireland (Chapter 14). Together with Susan Flavin and Ellen O'Carroll, McLatchie opens up a very fresh and stimulating dialogue between archaeobotanical evidence and historical records on the subject of fruit consumption in the context of the ERC project FoodCult. The paper explores the patterns of contemporary fruit consumption e.g. who ate fruit, how popular it was in Ireland during the 16th-17th c, what changes are associated with fruit consumption etc.

The section on plant foods closes with food for thought coming from the New World. The long research conducted by Christine Hastorf on the Archaeology of Food, plant food in particular, coupled with her ethnographic field work in the Andes, alerts all researchers of past foodways against static approaches that focus only on the material aspect of food and its compartmentalized study (Chapter 15). Contrary to all the conventional ways in which we have learnt to perceive archaeobotanical data, since they became an important element of archaeological inquiry with the birth of New Archaeology, plant remains correspond to elements of a connected world: all is connected in nature, the humans who feed upon nature and nature that is fed by humans is the message brought to us by this fascinating and original look into human-plant interaction.

The second part of the book focuses on the processing of food ingredients with an emphasis on plants and how they are cooked, from the point of view of cooking vessels and cooking installations. The first paper of this section presents original PlantCult results on Early Neolithic grinding and pounding stone tools from Early Neolithic southeastern Europe (Chapter 16). Ismini Ninou leads this paper that offers an overview of grinding and pounding tools; having Ninou's PhD material as a starting point the paper detects variability in the choice of grinding/pounding tool apparatus, allowing inferences for variable culinary practices in the region, perhaps related to different culinary identities among the first farmers. Another PlantCult contribution is led by Danai Chondrou and Maria Bofill; they offer a synthesis of their experimental and archaeological postdoctoral research on usewear generated by grinding plant food ingredients on stone tools. Conducted in close collaboration with Hara Procopiou, Roberto Vargiolu, Hassan Zahouani, Lambrini Papadopoulou and the stone-tools project team, the paper offers pioneering insights into how people used grinding tools at nine selected Neolithic and Bronze Age sites from southeastern Europe (Chapter 17). From the detailed analyses of the minuscule traces left on tool surfaces to the big picture, the paper by Tasos Bekiaris, Danai Chondrou and Ismini Ninou offers a unique and much needed overview of the contextual affinities related to grinding stone tools (Chapter 18); their work brings to the fore the multiple functions of grinding and pounding tools and their spatial associations in relation to daily and special events, as well as the living and the dead.

Cooking on the rocks is a question asked by the paper that follows, led by Tasos Bekiaris (Chapter 19). Thanks to a very unusual find from the Late Neolithic site of Avgi in northern Greece, stone slabs with traces of burning, he convincingly demonstrates, through ethnographic and experimental investigations, yet another way of cooking in the Neolithic, contributing further to our understanding of prehistoric diversity in food preparation. Carolin Hamon presents us with a thorough review of the grinding systems of northwestern continental Europe at the turn of the 6th mill BC (Chapter 20). Hamon reveals the highly selective choice of raw materials for the manufacture of grinding tools and the sophisticated know-how involved in the manufacture of tools that played a central role in daily tasks, mainly for grinding plant ingredients; the manufacturing traditions in the study area show features that connect it with Central Europe, yet, as farming spread to the northwest became modified through technological innovations.

From the grinding spaces of prehistoric sites, the volume moves on to examine cooking facilities that include pots and thermal structures. Anastasia Dimoula, Zoi Tsirtsoni and a large team of researchers and excavators bring together an impressive, original dataset that addresses the question of how cooking pots are identified archaeologically (Chapter 21). The paper offers a fresh look at an old question (cf. Vitelli 1989) through macroscopic and petrographic analysis of sherds from pots that could have been used for cooking in prehistoric Greece and Bulgaria. Through the massive amount of new data generated by the PlantCult project, the paper offers an overview of how cooking pots and thus cooking may have changed over time in a large part of southeastern Europe. The question of whether pots were used for cooking among early farming communities is addressed by Julien Vieugué, Monika Ramsey and Yoseph Garfinkel, this time to the East of the Aegean, in the southern Levant (Chapter 22). Another PlantCult contribution approaches cooking from the perspective of cooking installations. Led by PlantCult team members Evi Papadopoulou and Sandra-Prevost Dermarkar, this paper collects, in a systematic way, and for the first time, published evidence on cooking installations from the 3rd to the end of the 2nd mill BC, i.e. spanning the whole of the Bronze Age (Chapter 23). This newly collected evidence is discussed in combination with the knowledge generated on cooking pots by PlantCult, offering an interesting discussion of the multiple ways in which people in the same region and time period may have cooked their food, depending on seasonality and the context of food consumption; the paper offers a diachronic view on how the cooking apparatus changed over time in Bronze Age northern Greece and cautions against simplistic and overgeneralized statements about spatial and temporal changes in cooking spaces and cooking methods: as the paper emphasizes, there are many ways in which the cooking installations identified from Bronze Age northern Greece could have been used for food preparation. Ongoing research based on PlantCult data for the whole of Neolithic and Bronze Age Greece are expected to offer fascinating insights into prehistoric cuisine in the region. Last but not least in this series of papers on processing and cooking, the contribution by Lena Manakidou reaches out to the historic periods and offers us a panorama of vivid pictures of ancient Greek cooking (Chapter 24): breads, porridges, cakes and rusks, broths and pancakes are only a few examples of the impressive range of plant foods that could have been ground using special clay or stone equipment, cooked with the clay vessels or installations identified, without forgetting, however, the simple and straightforward cooking performed directly on ashes.

In the last section of this volume, archaeologists working in Greece and elsewhere, together with plant-breeders and modern cooks, share their experiences and contemplate the significance of archaeological work on past foodways for the present. Five articles offer insights on how ancient plant foods are perceived and communicated in the present and their potential for influencing future agricultural practices and food habits. Jerolyn Morrison (Chapter 25) offers a hands-on experience of cooking with plants using a Minoan cooking kit, combining her archaeological expertise in Bronze Age pottery from Crete and her expertise as a modern professional cook, active in the tourism sector. Her paper is a novel look into the archaeological record, a reflection on the practicalities of cooking with different tools and facilities, lentils and wild greens, highlighting the longue durée of plant-based food ingredients and dishes available in Crete. The cultivation of glume wheats in modern Greece is discussed by Paul Halstead (Chapter 26) who offers valuable insights as regards the interplay between the specific features of these cereals in form, growth requirements, processing and consumption, the fading tradition of their cultivation and the complex factors that contributed towards their revival in modern Greece in the last few decades. The paper by Kostas Koutis, Evangelos Korpetis, Poppy Ralli and the late Nikos Stavropoulos glimpses at the future of prehistoric wheats in Greece (Chapter 27). The paper focuses on *kaploutzas*, an old Greek einkorn landrace, and offers valuable insights as regards its origins, cultivation problems and potential in a modern economic environment, revealing how a nearly extinct, marginal cereal crop has generated its own market niche thanks to its special taste, dietary properties and the support of NGOs and scientific institutions. The surprising story of an unexpected plant food ingredient is told by Marcie Mayer (Chapter 28). The transformation of acorns into gourmet cookies, pasta and other foodstuffs, and the challenges and potential of re-introducing acorn flour as a novel food ingredient are presented in this paper, through the insights of an acorn food producer, based on the island of Kea. Acorns emerge as a gatherer-hunter food that perseveres to the present. Sailing westwards across the Mediterranean Sea, the paper of Anna Barberà, Sandra Lozano, Ferran Adrià, Ramon Buxó and Antoni Palomo (Chapter 29) takes us to that world-changing moment when crop cultivation reached the lands of gatherer-hunters of the Iberian Peninsula. The authors identify the foundations of the contemporary cuisine of the Iberian Peninsula in those first pioneers who introduced novel ingredients to the cuisines of the region: cereals and pulses, together with flax and opium poppy, as well as a range of processing and cooking steps for their culinary transformation formed a Neolithic cuisine, which, at the same time continued to embrace elements of the preceding Palaeolithic one. Last but not least, Bettina Arnold (Chapter 30) invites us to raise a glass full of ancient beer and cheer the opening up of interdisciplinary, scientific research into the past, to the public. Arnold emphasizes the significance of archaeological research into past foodways for modern communities, shares with the readers her own experience in recreating ancient ales in Milwaukee through the collaboration of scientists, universities, museums and businesses, inviting us all working on the subject to actively involve the public and educate it about past foodways in a tasty and inebriating way. We hope that this volume will stimulate further research in the domain of ancient foodways, plant food ingredients and recipes in particular.

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Chapter 1

Plant ingredients archived with *ArboDat* – evaluating regional food preferences and changes from crop remains, using the new archaeobotanical database for Greece

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Abstract

Archaeobotanical data from Neolithic northern Greece archived with the *ArboDat* database program have been analysed in a similar way to earlier studies on other parts of Europe. In this paper the cereals and pulse crops from 21 sites spanning the Early to the Final Neolithic in northern Greece are examined in order to detect trends in space and time, continuity, and changes due to environmental, economic or cultural factors. We take into consideration various taphonomic aspects affecting both the formation of the archaeobotanical record and the attempts to disentangle the choices of crops grown from site formation processes and retrieval biases.

Keywords: *ArboDat, Greece, database, charred plant remains, Neolithic, crops, PlantCult*

1.1 Introduction

The collective consumption of foodstuffs by common households, friends or neighbouring groups is one of the fundamental elements of human social bonds, widely explored in the anthropological and more recently archaeological literature (Dietler and Hayden 2001; Goody 1982; Hastorf 2017). Reciprocal invitations provide the basis for stable social relations between guests and hosts. Food is not just the sum of its ingredients, whether in times of peace and availability, or times of shortage leading to starvation and tensions. The expenditure of time and effort in transforming ingredients into meals and the appearance, taste and smell of dishes express the food culture of the hosts and the degree of their generosity and social status. According to many ethnographic examples from different parts of the world and based on archaeological features, tools and other finds, it is very likely that this was also the case in prehistoric times (Ertuğ-Yaras 1997;

in: Valamoti SM, Dimoula A, Ntinou M (eds) 2022, Cooking with Plants in Ancient Europe and Beyond: Interdisciplinary approaches to the archaeology of plant foods, Leiden: Sidestone Press, pp. 19-42.

Fig. 1.1 Map showing the Greek Neolithic sites mentioned in the text (map by Themis Roustanis, courtesy of PlantCult).

Halstead 1999, 2012; Hastorf 1998, 2017; Kreuz 2012, chapters 8-9; Kreuz et al 2020; Urem-Kotsou and Kotsakis 2007; Valamoti 2017).

Neolithic archaeological finds from the sites of Makriyalos (Pappa et al 2004) and Promachon-Topolnitsa (Koukouli-Chrysanthaki et al 2007; Tzevelekidi et al 2014; Valamoti 2007) provide clear archaeological evidence for feasting in northern Greece during the Late Neolithic (about 5300-4500 cal BC; Fig. 1.1). At Makriyalos, this most likely involved large numbers of people who may have assembled from a wide area (Pappa et al 2004; Vaiglova et al 2018). Besides these exceptional finds, food sharing and the expression of cultural identity through food consumption can also be inferred by a wide range of archaeological features, tools, vessels and other finds, for example, large open-air hearths as evidenced at the site of Kleitos in northern Greece (Ziota 2014). Such gatherings which involved food consumption would have probably acted as a means to provide solidarity in a group, maintain regional networks, negotiate status and power and resolve tensions (Ertuğ-Yaras 1997; Dietler and Hayden 2001). Considering the rich ethnographic evidence of feasting and food consumption in general, it appears particularly important to investigate regional similarities and differences in the range of crops and wild plants chosen as food by prehistoric societies in an attempt to detect food preferences through the choice of plant food ingredients (Hastorf 1998; Valamoti 2017). For this very important aspect of archaeobotanical work, a solid body of reliable and comparable archaeobotanical data is needed. This has been achieved for some parts of Europe, with regional syntheses of archaeobotanical data studying the expression of cultural identity through food. In these approaches, the choices of crops grown are not merely regarded as having been determined by environmental conditions but also as related to cultural choices (Kreuz et al 2014, 2020; Kreuz and Marinova 2017; Valamoti 2004, 2017).

Foodstuffs and the way of using them might be connected with the ecological potential of the landscapes inhabited, knowledge of resources used since childhood, or prestige enhancing innovations, locally invented or adopted through contact networks and population movement. Therefore, the reconstruction of the chronological development of food traditions within their biological and social contexts is one of the most fascinating subjects of bioarchaeological studies. The basis for such considerations and interpretations is a representative data set which allows the comparison of the local, regional or supra-regional developments of food ways through time. In order to provide such data, relational databases are very helpful.

One such database is *ArboDat 2016*, and its use in the European Research Council (ERC) PlantCult project and for the new archaeobotanical database of the whole of prehistoric Greece is discussed below. The ERC PlantCult project investigates plant food cultures of ancient Europe from the first farmers in the 7th mill BC to the first cities of the 1st mill BC (Valamoti et al 2017) and for this archaeobotanical data from prehistoric Greece were gathered. They included data already published as well as those generated by postgraduate research at the LIRA laboratory of the Aristotle University of Thessaloniki which have been entered into *ArboDat*. The aim was to allow comparisons over large areas and time spans not only within Greece but also with some other parts of Europe with data in *ArboDat*. In our paper we focus, as a first attempt, on Neolithic northern Greece and explore the main crops used there and in the wider surrounding region.

1.2 *ArboDat* – the vision of archaeobotanical "big data"

In most European countries, ambitious political efforts are made to establish data inventories for various purposes. Modern archaeobotanical investigations aim to answer important biological and historical questions beyond political borders. As a consequence, a supra-regional data exchange is required, which can compare standardized data from different research areas and from different archaeobotanical laboratories in detail and with high resolution. The archaeobotanical database program *ArboDat* has been developed for this purpose (Kreuz and Schäfer 2002, 2004, 2012).

ArboDat is based on Microsoft Access and comprises a core program formed of three parts for data archiving, as well as for the handling and evaluation of the archaeobotanical and related ecological and archaeological data. One part contains the utility program including all definitions, calculations, join-properties and control elements. Furthermore, it contains forms and reports, pre-programmed queries and interactive elements for flexible data evaluation and for generating lists of taxa. The second part contains fixed terms and definitions in the structural data. They are classified thematically in Access tables which can be continuously complemented if necessary. The third part contains the actual results, comprising all data on the archaeological sites, features, samples and identified plant remains.

Under normal working conditions this division into three parts is not noticeable as *ArboDat* acts as a unified database. The division has practical advantages for the combination and separation of data pools, as well as for program updates. In addition, the division of data from the functional components allows for a separate exchange or adaptation of partial databases, for example, for working on different continents or on different scientific questions. *ArboDat* combines both the flexible data management of each user group and the possibility to integrate and exchange the data within a centralized system or between different groups as well.

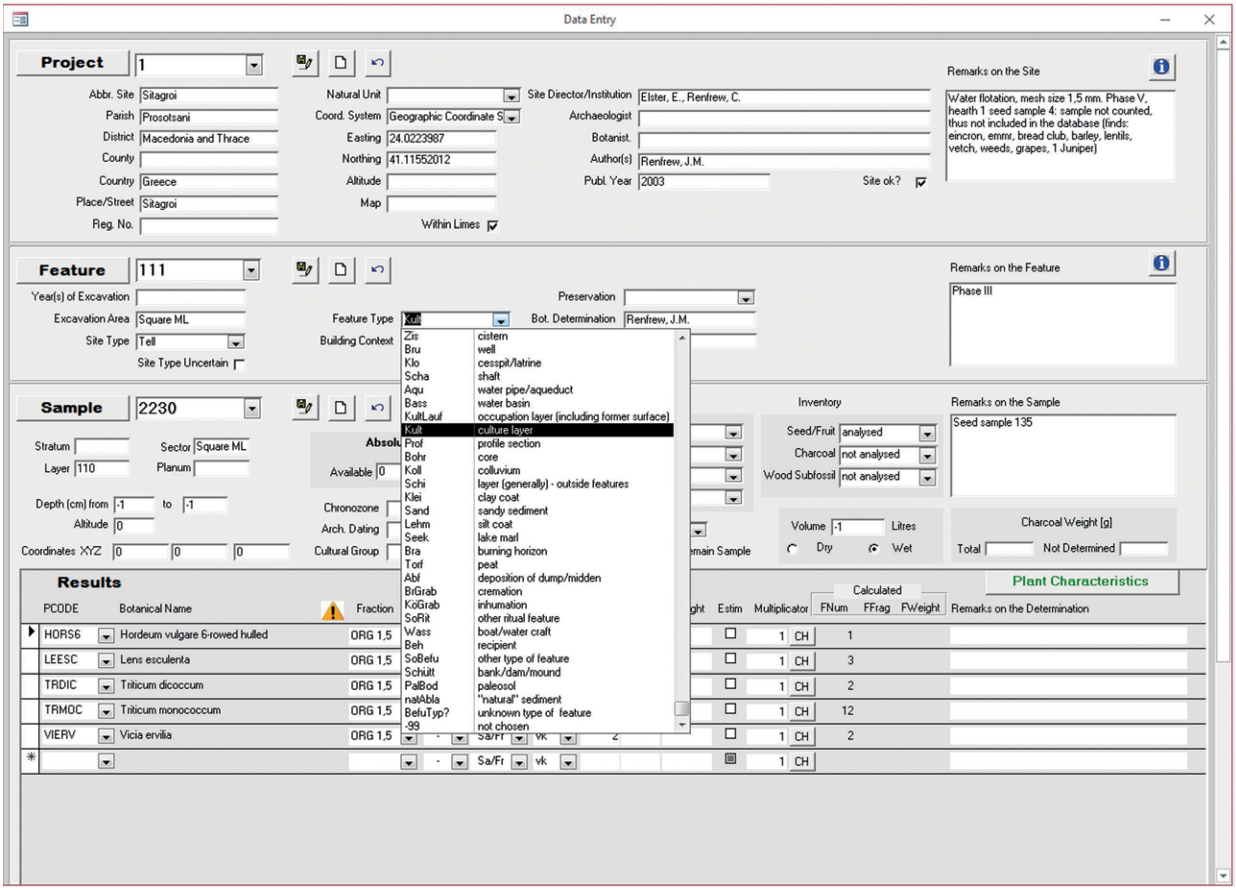


Fig. 1.2 The data entry of *ArboDat* is carried out at different information levels and facilitated by pull-down menus with fixed terms (here the feature types are shown).

Included in the structural data of *ArboDat* is a list of 5000 plant taxa, each one defined by a plant code (PCODE) and a botanical name. The most commonly used taxa are complemented by their German, English, French and Italian names and some other parameters following defined floras for the different areas cited in the *ArboDat* manual. Further ecological and other information for each taxon can be recorded individually. Apart from the plant codes and the botanical names, other pre-defined terms, such as for the type of site, feature, plant remains etc are available from pull-down menus during data entry (Fig. 1.2). This arrangement of the data ensures that it is recorded in a uniform and standardized way by the whole user community in Europe, where it has been widely applied with great success (Kreuz et al 2014; Woodbridge et al 2021).

The basics and conditions of these structural data have been discussed in detail and agreed by the *ArboDat* user group in meetings during all the years of its development (Kreuz 2013, 2014, 2015b, 2016a; Fig. 1.3). This process revealed similarities and differences in the archaeological practices of the different European countries, reflected for example in problems of differing regional archaeological chronologies and terms for archaeological features relevant for the standardisation of the data entry and for supra-regional data evaluations. One important methodological result of the discussions during the meetings was the agreement about identifications, plant names, the counting of fragments, etc. Everything is explained in detailed *ArboDat* manuals which are available in German and English, so that beginners can easily learn to use it (Kreuz and Schäfer 2022a, b).

ArboDat has proved to be a valuable time-saving working tool both in daily routine archaeobotanical work and in research. Its development reaches back more than twenty years, when the first version of the archaeobotanical database program was begun by Angela Kreuz, at Landesamt für Denkmalpflege Hessen (LfDH) in Wiesbaden. This was done as part of a research program funded by the Deutsche Forschungsgemeinschaft (DFG), in which 915,969 identified archaeobotanical remains from fifty Iron Age Celtic, Germanic and Roman sites were studied (Kreuz 2005). Since then until 2016, a number of functional program upgrades have been produced by the archaeobotanical working group in Wiesbaden.

Fig. 1.3 For the development of *ArboDat* and the standardisation of terms and methods the regular meetings and the discussion of the user group have been very important and fruitful.

In the beginning, *ArboDat* was available only in German. However, it became clear among an increasing number of scientists that using it more widely would facilitate a supra-regional exchange of standardized data in future. Therefore, based on discussions with Marie-Pierre Ruas (CNRS-UMR 7209, Muséum national d'Histoire naturelle MNHN/Paris; Kreuz et al 2006) and Adela Pokorna and Dagmar Dreslerova (Institute of Archaeology, Archeologický ústav AV ČR, Charles University, Prague), the working group in Wiesbaden started a joint project for the translation of the user interfaces and evaluation facilities of *ArboDat* version 2013 into English, together with Elena Marinova (then University of Leuven/Royal Belgian Institute of Natural Sciences/Brussels) and colleagues from the MNHN via the BIOARCH network led by Jean-Denis Vigne (Kreuz 2015a; Fig. 1.3).

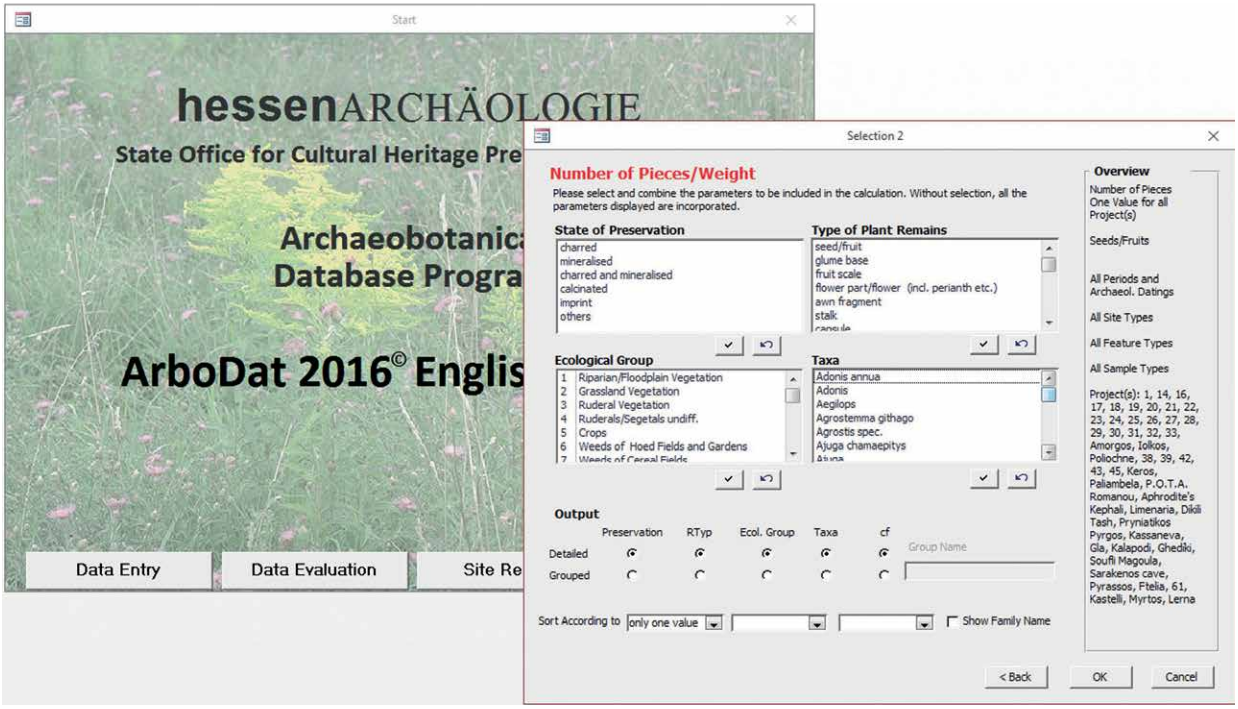


Fig. 1.4 The interactive choice menus of *ArboDat* allow for a detailed data evaluation.

Since then, *ArboDat* and the additional tools *TaxaTransfer* and *TaxaMerge* have been available as German and English versions (Kreuz 2015b, 2016a). The program and detailed German and English manuals have been given free of charge to archaeobotanical researchers on their agreement to use the same plant codes and other structural terms in order to allow easy data exchange and studies of standardized data collected by different working groups in the future.

The final program version of *ArboDat* 2016 has a completely revised program structure and new interactive functions for complex scientific data evaluations and as a basis for visualization of the data (spreadsheet diagrams, below). The programming has again been financed by DFG and LfDH in Wiesbaden. The interactive data evaluation allows the generation of tables with either the number of remains or their weight, or percentage of occurrence (frequency, or ubiquity), or concentration values. The function *TaxonSearch* allows searching for a certain taxon within the database. The results of all evaluations are displayed as Excel format spreadsheets with headers for the lines and columns and with values for sums, concentrations, frequencies etc. The taxa and their related values can be listed per site, feature, sample or fraction, also for several sites within one file. The botanical names are generated automatically in italics and the common names added according to the language chosen and the defined floras of the different areas. The interactive choice of different parameters and the possibility to arrange data in groups allows a quick, flexible and useful data evaluation of both small and large data sets (Fig. 1.4).

A further valuable tool in the *ArboDat* 2016 package is *TaxaMerge* for merging taxa lists with different numbers of rows into a single table with columns from both source tables listed in series. *TaxaTransfer* is another tool, which can be used to import lists of taxa from Excel spread sheets into *ArboDat*. This is important for archiving old data predating *ArboDat*. *ArboDat* 2016 is now being used by more than forty archaeobotanical working groups in Austria, Belgium, Bulgaria, Egypt, France, Germany, Great Britain, Greece and Switzerland. In 2017 the *ArboDat* project was transferred to the archaeobotanical working group at the Niedersächsisches Institut für historische Küstenforschung (NIhK) in Wilhelmshaven, Lower Saxony, to be continued there.

1.3 The PlantCult Project in Greece

For the PlantCult project, several databases had to be constructed in order to record the different lines of evidence relating to plant food preparation, such as grinding stones, cooking pots and hearths. The ultimate goal of this effort was to integrate this evidence and attempt a long-term narrative of past food use in the PlantCult study area. This effort has proven a challenge, with interesting lessons to be learnt. Until now, different databases were used to integrate various categories of

Fig. 1.5 Mass finds of charred edible plant species give hints for the reconstruction of former food preparation. Above: einkorn grains (*Triticum monococcum*) from Neolithic Dikili Tash, Greece, and winter cherry (*Physalis alkekengi*) and flax seeds (*Linum usitatissimum*) from the LBK sites Kilianstädten and Niedertiefenbach, Hesse/Germany. Below: cooking of einkorn for bulgur preparation (PlantCult experimental cooking) and a pea stew with *Physalis* and an emmer-linseed flatbread (einkorn pictures by Tania Valamoti, others by Angela Kreuz).

data, such as stone tools (Bekiaris et al 2020) and cooking pots (Dimoula et al 2022). Integration of the different lines of evidence was done only at a coarse level, plant remains having been considered to provide an important feedback to the artefact studies.

Archaeobotanical data for the whole of Greece were collected under the direction of Tania Valamoti and Chryssa Petridou (Aristotle University of Thessaloniki) and have been archived with *ArboDat* in a central database for Greece to provide a quantitative basis for the reconstruction of food culture there. In this paper the archaeobotanical data set from Neolithic northern Greece is discussed as a regional case study aiming to assemble a picture of the Neolithic evidence and to enable comparisons with Neolithic communities further north. This approach, as part of the PlantCult project, will make the data widely accessible for future analyses.

1.4 Archaeobotanical finds and their interpretation – a challenge

The preservation of remains of food plants depends on various factors. Today, the original land surface of flat settlement sites (open settlements), in contrast to raised tells, has usually been eroded away. Therefore, only features that were dug into the ground are mainly preserved, such as different kinds of pits, postholes and ditches. Human behaviour and varied use of space can lead to differential on-site representation of crops and other plant remains, as is the case for example with sites in Neolithic northern Greece which are rich in glume wheat chaff and grain (Valamoti 2004; Valamoti and Charles 2005).

Basically, whether archaeological deposits are either dry or waterlogged determines the amount and the species richness of the plant material preserved. The evidence from the Neolithic sites in northern Greece and the other regions examined here relies completely on charred plant remains. This means that the plant remains were preserved only if they were charred in either an accidental fire or in the gradual accumulation of burnt debris around a hearth (Valamoti 2004). Since food which was eaten raw, like herbs and fruits collected from the wild, fresh legumes or spicy oil plant seeds had a lower chance of being preserved by charring, they are under-represented in assemblages from dry mineral soil sites (Dennell 1976; Jacomet 1999; Jacomet et al 1999; Kreuz and Marinova 2017). Luckily, everyday crops were charred and thus well preserved due to their connection with cooking

Archaeological period	Early Neolithic		Middle Neolithic			Late Neolithic		
Site name	**Revenia**	**Paliambela**	**Servia**	**Apsalos**	**Sitagroi**	**Anarghiri III**	**Servia**	**Toumba Kremastis Koiladas**
Site type	**open settlement**	**open settlement**	**open settlement**	**open settlement**	**tell**	**lakeside dwelling**	**open settlement**	**tell**
No of samples	**111**	**60**	**54**	**93**	**47**	**73**	**7**	**51**
No of features	**111**	**60**	**54**	**93**	**47**	**73**	**7**	**51**
Sample volume (litre)	**2821**	**not provided**	**not provided**	**partly provided**	**not provided**	**321.5**	**not provided**	**partly provided**
Cereals								
Triticum monococcum								
grain	75	36	782	62	848	28938	18	131
glume bases	47	49	273	1209		2807	3	398
Triticum dicoccum								
grain	8	17	572	13	221	10290	192	96
glume bases	1	6	654	205	34	699	20	8
Triticum timopheevii								
grain						150		
glume bases				1939		700		153
Triticum aestivum s.l./*durum*/*turgidum*								
grain		2			1	254		1
rachis internodes		1				181		
Hordeum distichon/vulgare								
grain	89	30	913	52	22	1786	163	40
rachis internodes	21	4	2	100		204		4
Legumes								
Lens culinaris	24	14	6958	228	1	1	251	224
Lathyrus sativus/cicera		2	1235	6		49	239	67545
Vicia ervilia	3	1		1	19		2	5
Pisum sativum				17	2	2	2	
Oil/Fibre plants								
Linum usitatissimum								
seeds	3		30			2		1

Table 1.1 Summary of the absolute numbers of crop plants per site and archaeological period.

fires and hearths (Fig. 1.5; Kreuz 2012 chapter 3; Kreuz and Marinova 2017; Kreuz et al 2020; Valamoti 2004, 2015).

The material retrieved from an excavation is not only influenced by the chance of plants coming into contact with fire but also by their likelihood of surviving this contact and the carbonization process. In general, cultivated oil plants, due to their oil content, are less likely to preserve when in contact with fire as shown experimentally (Märkle and Rösch 2003) and this probably accounts for the lower visibility of these plants in the archaeobotanical record (Kreuz and Marinova 2017; Valamoti 2017).

Appearance in the archaeological record is also largely determined by the archaeobotanical sampling strategy used. The number and size of samples and the number of different features investigated per site, the feature types and the processing of the samples are all factors which influence the archaeobotanical record from them (Antolín et al 2017; Jones and Halstead 1995; Kreuz et al 2020; Kreuz and Marinova 2017; Oeggl 2009; Tolar et al 2010; van der Veen 1983, 2007; Valamoti 2004, 2005). Therefore, the absence of certain remains, plant parts or taxa or their lower frequency or lower concentration values among charred plant remains cannot be taken at face value and interpreted as reflecting the actual importance of the various plants used by the members of a past community.

The difficulties described above can be overcome only by representative data sets. The more sites, features and samples which are investigated fully quantitatively, the greater the

				Late Neolithic						Final Neolithic		
Kleitos	**Makriyalos**	**Kyparissi**	**Koroneia**	**Dimitra**	**Sitagroi**	**Dikili Tash**	**Makri**	**Kleitos**	**Mandalo**	**Sitagroi**	**Arkadikos**	**Dikili Tash**
open settlement	**open settlement**	**open settlement**	**open settlement**	**tell**	**tell**	**tell**	**tell**	**open settlement**	**tell**	**tell**	**tell**	**tell**
89	**53**	**40**	**58**	**48**	**45**	**68**	**21**	**9**	**24**	**90**	**25**	**21**
89	**53**	**40**	**58**	**48**	**45**	**68**	**21**	**9**	**24**	**90**	**25**	**21**
768	**4835**	**339**	**260**	**not provided**	**not provided**	**partly provided**	**824.5**	**57**	**partly provided**	**not provided**	**477**	**400**
194	103	331	6	137	2440	12212	314	1113	635	2289	302	837
155	22606	1943	44		16	219	12228	107	877	4	2923	62
1530	688	656	1	742	312	9706	86	7	7305	272	165	73
167	3685	306	6		120	357	1257		2122	18	675	
		449										
1654	919	1392	11				2762	11	66		983	
		119		18	41		53				24	
3	8	4					145		1		14	
20	167	1396	12	214	251	2463	660	3711	253	61783	1594	1489
7	373	122					1077	4			46	
39	533	43	1	35	132	8710	577	12	748	114	7547	728
7	63	3	1	8		467	37	6986	13	24	666	1846
45	5	18	1	497		883	187		5563	1200		12539
	18				33	1	157		11	22	4248	
	2182						12		145		182	2

chance of obtaining reliable data for the archaeobotanical interpretation. It is clear that for the management of such “big data”, relational databases are the best solution. In the following section, a case study based on *ArboDat* is discussed, to search for the most important ingredients of ancient plant foods used in Neolithic northern Greece.

1.5 Cultivated crops in Neolithic northern Greece

The data explored here are based on a first attempt to generate a large database of Greek plant remains with the aid of *ArboDat*. While this is ongoing work, we discuss the Neolithic of northern Greece here because the data from this area were assembled using similar methods and are therefore reliably comparable. We have selected 21 sites that span from the Early Neolithic (6500-5800 cal BC), the Middle Neolithic (5800-5400 cal BC), the Late Neolithic (5400-4600 cal BC) through to the Final Neolithic (4600-3300 cal BC; Tables 1.1-1.3).

The analysis considers a total of 1087 samples (Table 1.1; for the methodology see Valamoti 2004). Sampling was carried out at most sites on a judgement or a systematic basis. Soil was processed by flotation with a smallest mesh size of 300 microns at most sites. At Nea Nikomedeia the sampling procedure selected for visible concentrations of remains only and used rather large mesh sizes, thus introducing biases against the retrieval of chaff and small seeds of wild plants, so this material has not been included in this analysis. For Paliambela the publication of the assemblage was not done on a sample by sample basis, therefore the

Archaeological period	EN	Middle Neolithic			Late Neolithic		
Site name	Revenia	Servia	Apsalos	Sitagroi	Anarghiri III	Servia	Toumba Kremastis Koiladas
Site type	open settlement	open settlement	open settlement	tell	lakeside dwelling	open settlement	tell
No of samples	111	54	93	47	73	7	51
No of features	111	54	93	47	73	7	51
Sample volume (litre)	2821	not provided	partly provided	not provided	321.5	not provided	partly provided
Cereals							
Triticum monococcum							
grain	27	46	39	64	96	57	59
glume bases	15	37	85		74	29	33
Triticum dicoccum							
grain	5	59	11	51	89	86	55
glume bases	1	52	43	15	59	43	8
Triticum timopheevii							
grain					26		
glume bases			72		45		35
Triticum aestivum s.l./*durum/turgidum*							
grain				2	36		2
rachis internodes					19		
Hordeum distichon/vulgare							
grain	33	57	37	15	62	86	35
rachis internodes	9	4	23		22		2
Legumes							
Lens culinaris	14	85	46	2	1	86	39
Lathyrus sativus/cicera		43	6		3	43	59
Vicia ervilia	2		1	19		29	10
Pisum sativum			2	4	3	14	
Oil/Fibre plants							
Linum usitatissimum							
seeds	3		20		1		2

Table 1.2 Frequency values (percentage of occurrence in the samples; ubiquity) calculated per site and archaeological period for the charred crops. For Paliambela the publication of the assemblages was not done on a sample by sample basis, therefore the data from the site are not shown in the table and relevant diagrams.

results could not be included in all the analyses presented. Moreover, for the sites Apsalos, Dikili Tash, Mandalo and Toumba Kremasti Koiladas, the sample volumes were not all recorded, and for Dimitra, Paliambela, Servia and Sitagroi, no information on sample volumes is provided in the publications. As a result, these sites or samples have not been included in the concentration calculations (Table 1.3; for the site locations see map Fig. 1.1).

Our results offer an overview of the range of cereal and pulse crops that may have been used as food and which have been identified in the archaeobotanical record. The largest number of sites, which also corresponds to the largest number of samples studied from the Neolithic of northern Greece, is dated to the Late Neolithic (around 5400 cal BC, Tables 1.1-1.3), being partly contemporary with the Early Neolithic Linearbandkeramik (LBK, Linear Pottery Culture) of Central Europe. Therefore, the discussion focuses on this period and the following one, the Final Neolithic. Patterns that might emerge from our analysis may well be because of an under-representation of the earlier periods and do not allow comparisons of changes with time. For this reason, we have made more general observations about past food ways and interactions of people with their environment. As archaeobotanical work continues, hopefully this subject will be better addressed in the future when data archiving is completed.

Late Neolithic								Final Neolithic				
Kleitos	**Makriyalos**	**Kyparissi**	**Koroneia**	**Dimitra**	**Sitagroi**	**Dikili Tash**	**Makri**	**Kleitos**	**Mandalo**	**Sitagroi**	**Arkadikos**	**Dikili Tash**
open settlement	**open settlement**	**open settlement**	**open settlement**	**tell**	**tell**	**tell**	**tell**	**open settlement**	**tell**	**tell**	**tell**	**tell**
89	**53**	**40**	**58**	**48**	**45**	**68**	**21**	**9**	**24**	**90**	**25**	**21**
89	**53**	**40**	**58**	**48**	**45**	**68**	**21**	**9**	**24**	**90**	**25**	**21**
768	**4835**	**339**	**260**	**not provided**	**not provided**	**partly provided**	**824.5**	**57**	**partly provided**	**not provided**	**477**	**400**
40	40	73	2	46	67	84	95	100	88	47	80	76
39	100	43	29		2	12	95	67	63	1	92	14
53	25	68	2	96	53	87	81	44	92	41	80	24
7	81	28	5		18	7	86		67	4	60	
		45										
85	57	58	12				95	11	29		72	
		43		6	2		62				36	
1	6	3					81		4		28	
10	43	78	14	56	31	71	95	33	83	33	92	86
4	38	28					81	11			36	
26	55	33	2	42	24	96	76	22	88	16	100	76
7	13	8	2	15		59	57	33	25	2	32	57
6	6	8	2	67		78	86		58	31		90
	9				16	1	48		4	2	76	
	23						33		33		60	10

1.6 The Neolithic cereals

The northern Greek Neolithic cereals include mainly einkorn (*Triticum monococcum*), emmer (*T. dicoccum*) and barley (*Hordeum distichon/vulgare*), both in terms of absolute numbers (Table 1.1) and ubiquity (Table 1.2). Timopheevi's wheat (*Triticum timopheevii*) and free-threshing wheat (*T. aestivum* s.l./*durum/turgidum*) are less frequent (Tables 1.1-1.3; Figs 1.6-1.14; Valamoti, 2023). As the number of samples from the different sites varies, the lower the number of samples, the higher the ubiquity value can be. Therefore, the results from Late Neolithic Servia and Makri as well as the Final Neolithic sites apart from Sitagroi should be interpreted with care (Table 1.2; Figs 1.6-1.8).

When evidence from cereal grain is examined einkorn, emmer and barley seem to be dominant at most sites, while naked wheat appears at 9 of 21 sites and with lower values (Fig. 1.12, Table 1.1). However, when the evidence from chaff is considered alone, the picture changes for free-threshing cereals: barley and naked wheat rachis appear considerably less frequently in the results and in lower numbers, in contrast to glume wheat chaff (Figs 1.7, 1.13). While these free-threshing cereals were probably processed outside the settlements, the remains from the early stages of crop processing may have been deposited at least partly elsewhere and therefore had a small chance of being charred. In addition, rachis fragments seem to be more fragile when charred compared to spikelet forks (Boardman and Jones 1990). The under-representation of barley chaff in chaff-dominated assemblages is most likely to be due to a different way of processing this free-threshing cereal, so it has a different and reduced chance

Archaeological period	EN	MN	Late Neolithic			
Site name	Revenia	Apsalos	Anarghiri III	Toumba Kremastis Koiladas	Kleitos	Makriyalos
Site type	open settlement	open settlement	lakeside dwelling	tell	open settlement	open settlement
No of samples	111	64	36	21	84	43
No of features	111	64	36	21	84	43
Sample volume (litre)	2821	902	233	391.7	714	3266
Cereals						
Triticum monococcum						
grain	0.0266	0.0499	13.6073	0.1557	0.2129	0.0153
glume bases	0.0167	0.7406	3.5279	0.3064	0.2171	3.3166
Triticum dicoccum						
grain	0.0028	0.0111	2.5622	0.0894	0.9580	0.2103
glume bases	0.0004	0.1242	0.7468	0.0153	0.2311	0.8380
Triticum timopheevii						
grain			0.0944			
glume bases		1.3581	0.5536	0.1634	2.1555	0.1494
Triticum aestivum s.l./*durum*/*turgidum*						
grain			0.0987	0.0026		
rachis internodes			0.0730		0.0042	0.0024
Hordeum distichon/vulgare						
grain	0.0315	0.0377	1.5429	0.0230	0.0266	0.0245
rachis internodes	0.0074	0.0565	0.7725		0.0098	0.0291
Legumes						
Lens culinaris	0.0085	0.2106	0.0043	0.0217	0.0504	0.1277
Lathyrus sativus/cicera		0.0067		2.3551	0.0098	0.0187
Vicia ervilia	0.0011			0.0077	0.0602	0.0015
Pisum sativum		0.0177	0.0021			0.0055
Oil/Fibre plants						
Linum usitatissimum						
seeds	0.0011	0.0255		0.0026		0.6660

Table 1.3 Concentration values (counted items/litre) calculated per site and archaeological period for the charred crops (sites where the sample volumes were not available or only partly have been excluded). Mass finds excluded.

of being preserved by charring on site. Both chaff and grain of free-threshing wheat appear to be generally scarce, with the exception of Makri (Figs 1.12-1.13).

As the "new glume wheat", now identified as *Triticum timopheevii* (Czajkowska et al 2020), is recognisable primarily by its chaff (Jones et al 2000; Kohler-Schneider 2003), the picture obtained from chaff remains becomes different compared to that obtained from grain among the sites (Figs 1.12-1.13). *Triticum timopheevii* chaff is, for example, present at Middle Neolithic Apsalos and Late Neolithic Kleitos in a large proportion. Its absence from Servia may be due to the fact that when the material was studied, the new glume wheat had not yet been recognised in the archaeobotanical record. A re-examination of the finds from Servia would therefore be worthwhile. At sites where *T. timopheevii* chaff remains are abundant, it is possible that at least some of the grains previously identified as emmer may correspond to Timopheevi's wheat. *T. timopheevii* appears very prominently in western Macedonia at the Late Neolithic sites of Kleitos and Toumba Kremastis Koiladas and it has been found more recently from Koroneia and in large quantities from Kyparissi in central Macedonia (Figs 1.1, 1.13; Karathanou 2009; Lathiras 2020; Paraskevopoulou 2019; Stylianakou 2013). This evidence fits with that obtained from the Late Neolithic sites Makriyalos and Makri and the Final Neolithic Arkadikos, from where the new glume wheat was first identified (Jones et al 2000). It may also have been present at Dikili Tash on the basis of certain wheat grains identified as cf. *T. timopheevii* grain (Kokkidou 2018). Its chaff is absent from the two Early Neolithic sites and Dikili Tash, which might be interpreted as differences in the

Late Neolithic					Final Neolithic		
Kyparissi	Koroneia	Dikili Tash	Makri	Kleitos	Mandalo	Arkadikos	Dikili Tash
open settlement	open settlement	tell	tell	open settlement	tell	tell	tell
23	58	44	14	7	15	14	13
23	58	44	14	7	15	14	13
213	262.5	2388.3	661.5	59.5	1545	388	718.5
0.6573	0.0229	2.4097	0.2343	18.5882	0.3113	0.6521	0.1781
2.8122	0.1676	0.0080	9.2880	1.7143	0.5398	2.3067	0.0863
0.3192	0.0038	1.1975	0.0484	0.1176	4.0110	0.2603	0.0905
0.3568	0.0229	0.0130	0.4263		1.2926	1.2758	
0.5728							
2.6385	0.0419		1.6085	0.1849	0.0427	0.9124	
0.2535			0.0574			0.0593	
			0.1376			0.0284	
0.8498	0.0438	0.3048	0.5518	0.0336	0.1528	3.7732	1.9791
0.1737			0.4717			0.1108	
0.1432	0.0019	2.3891	0.7256	0.0336	0.2647	5.1082	0.9436
0.0094		0.0582	0.0121	0.8067	0.0078	0.9794	2.5511
0.0845	0.0038	0.1512	0.2328		0.6861		4.3215
		0.0004	0.1723		0.0071	3.0464	
			0.0106		0.0848	0.3943	0.0014

choice of crops (Kokkidou 2018; Valamoti 2004; Valamoti and Jones 2003).

Further to the north, at Bulgarian Neolithic and Central European sites, the occurrence of the "new glume wheat" has been published for just a few sites and, in contrast to the Bulgarian tell sites, it has so far been found from LBK settlements as isolated chaff finds only (Heidgen et al 2020; Herbig et al 2013; Hristova et al 2019; Kreuz 2012; Kreuz and Marinova 2017; Kreuz et al 2020; Marinova 2011; Marinova and Valamoti 2014). In Serbia it is prominent at some sites (Filipović and Obradović 2019) and it has recently been identified from Neolithic sites in Turkey as well (Ulaş and Fiorentino 2021). In Neolithic times it still appears to have been quite rare, which has to be confirmed by future studies.

The variation in the choice of glume wheats has been associated with differences of food ways and the origins of the first farmers in Greece (Valamoti 2004, 2017). Unlike earlier suggestions that *T. timopheevii* may have been a weed of einkorn crops in Neolithic Greece (Jones et al 2000), the northern Greek evidence examined here suggests that it was grown as a crop in its own right at some sites. It dominates individual samples, for example from Middle Neolithic Apsalos (Valamoti 2006) and Late Neolithic Kyparissi (Lathiras 2020). As mentioned above, its occurrence at 11 out of 21 sites is based almost exclusively on chaff remains, therefore it is certainly under-represented among the cereal grain finds (Figs 1.12-1.13). A further example is the variable apparent dominance of either einkorn or emmer, depending on whether one considers grain or chaff (Figs 1.9, 1.10, 1.12, 1.13). These examples clearly show that in order to explore changes in crop choices over time, it is necessary to question the data in various and fully quantitative ways, taking into consideration crop processing, archaeological context and potential taphonomic processes before interpreting the importance of a crop in diet or the relationship of certain crops to cultural identities (Kreuz and Marinova 2017; Valamoti 2005).

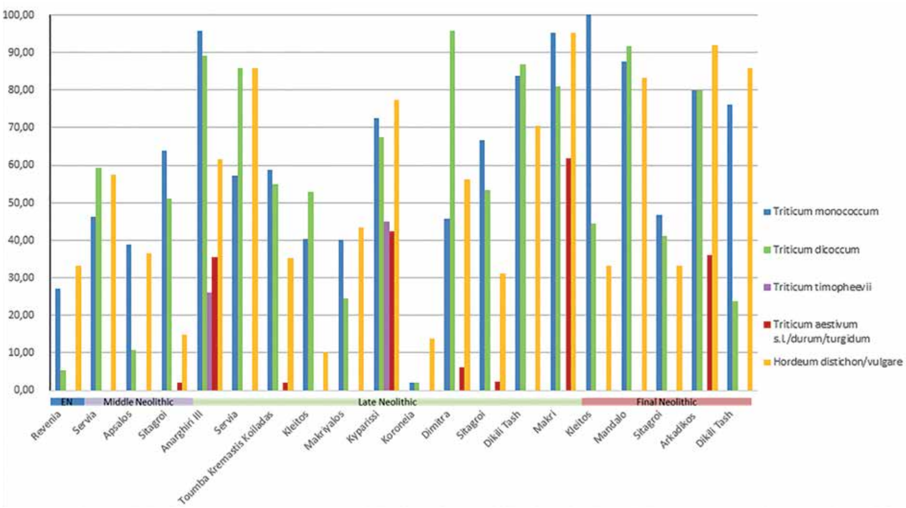


Fig. 1.6 Frequency values (percentage of the occurrence within the samples; ubiquity) calculated per site for charred cereal grains (mind the different sample numbers, Table 1.1).

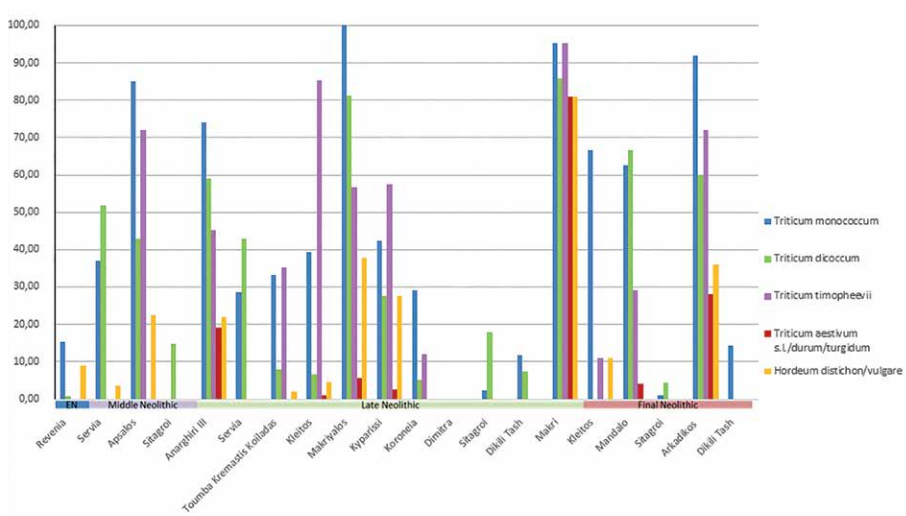


Fig. 1.7 Frequency values (percentage of occurrence in the samples; ubiquity) calculated per site for charred cereal chaff (note the different sample numbers, Table 1.1).

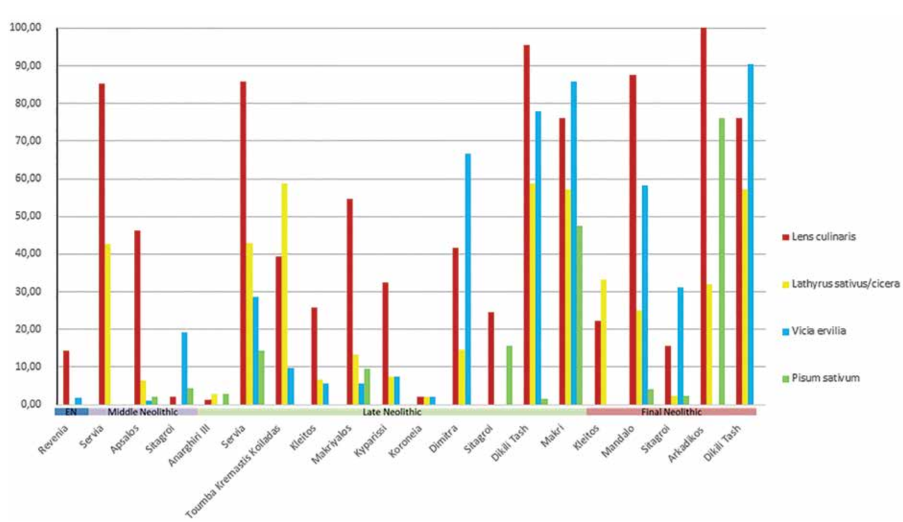


Fig. 1.8 Frequency values (percentage of occurrence in the samples; ubiquity) calculated per site for charred pulse seeds (note the different sample numbers, Table 1.1).

Fig. 1.9 Concentration values (pieces/litre) calculated per site for charred cereal grains (mass finds excluded).

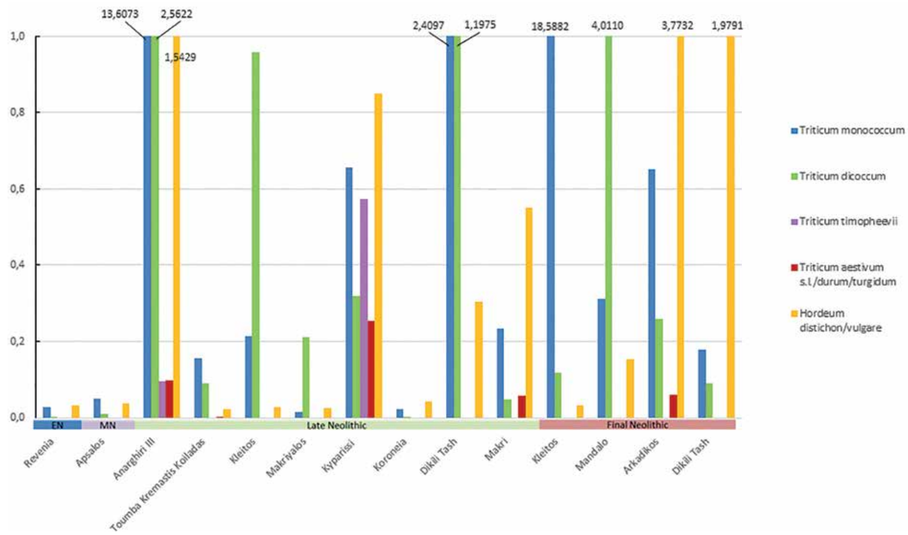


Fig. 1.10 Concentration values (pieces/litre) calculated per site for charred cereal chaff (mass finds excluded).

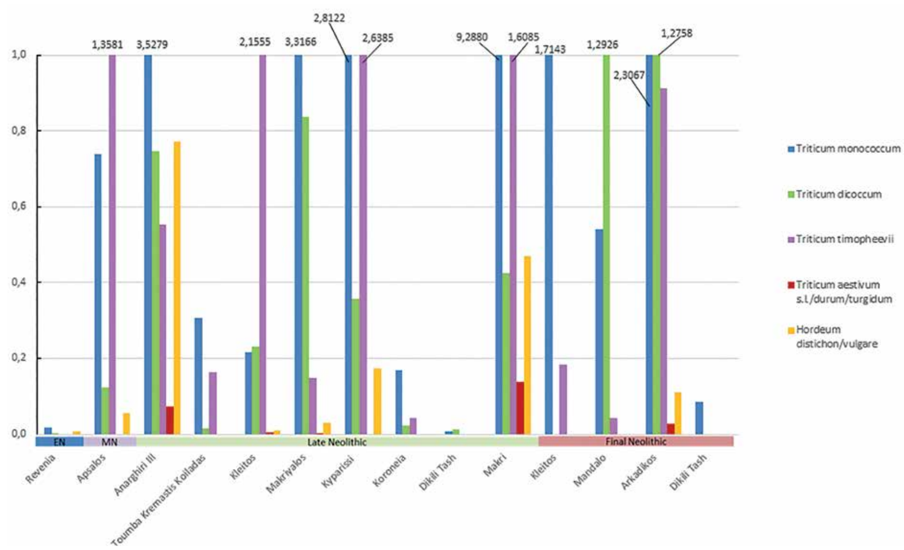
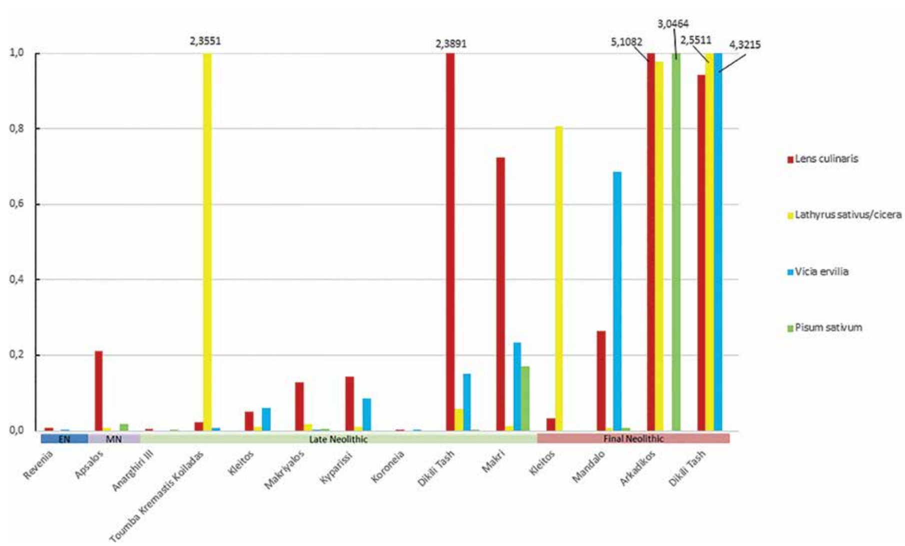


Fig. 1.11 Concentration values (pieces/litre) calculated per site for charred pulse seeds (mass finds excluded).



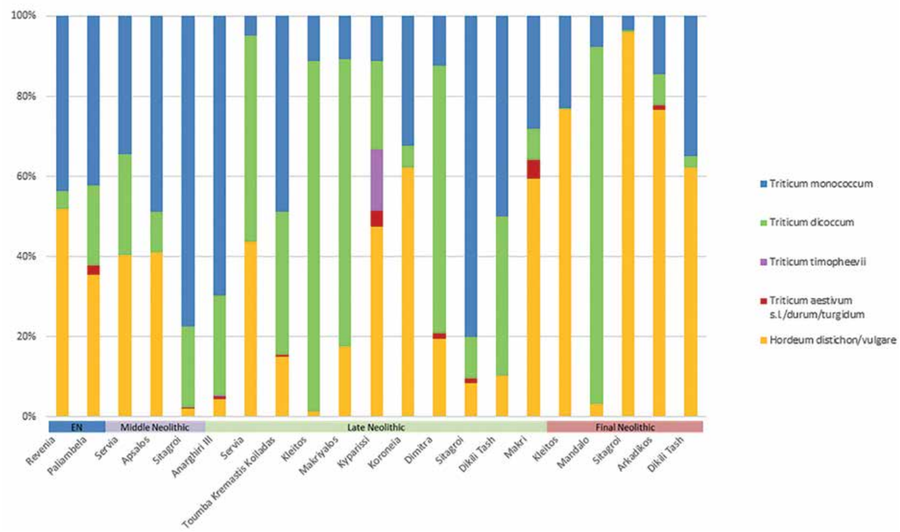


Fig. 1.12 Percentages of absolute numbers per site for charred cereal grains.

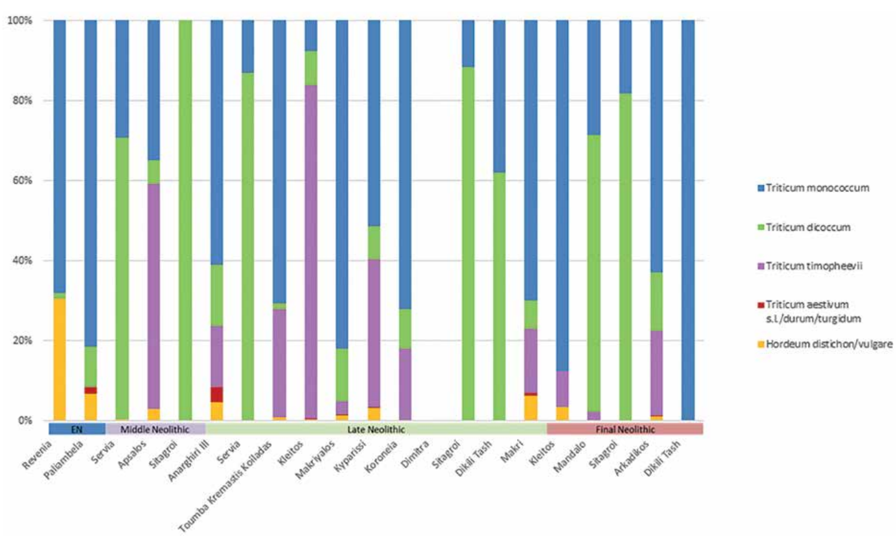


Fig. 1.13 Percentages of absolute numbers per site for charred cereal chaff.

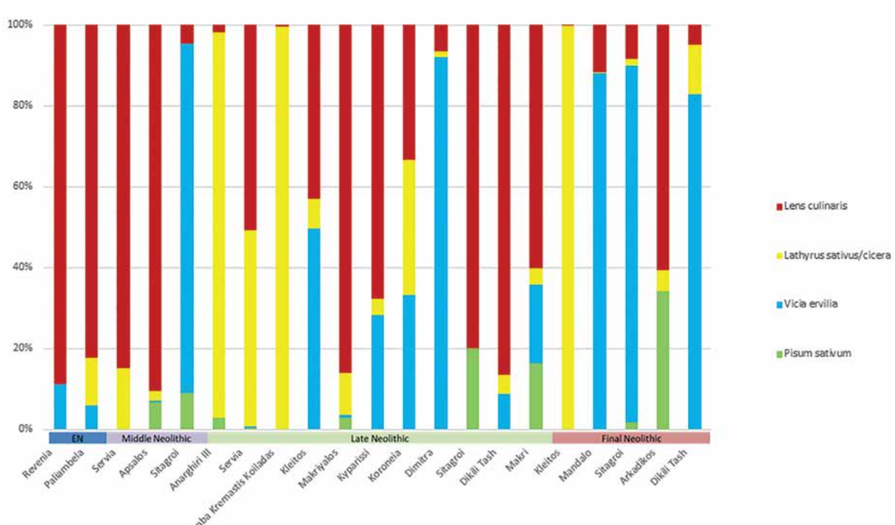


Fig. 1.14 Percentages of absolute numbers per site for charred pulse seeds.

1.7 Pulses in northern Greece

Four pulses were cultivated during the Greek Neolithic: lentil (*Lens culinaris* Medik.), grass pea/wild grass pea (*Lathyrus sativus* L./*cicera* L.), pea (*Pisum sativum* L.) and bitter vetch (*Vicia ervilia* (L.) Willd. The finds indicate a dominance of lentils throughout the northern Greek Neolithic, followed by grass pea and bitter vetch (Figs 1.8, 1.11, 1.14). This is reflected both by the relative proportions of the total number of seeds per site but also by their ubiquity (Fig. 1.8). It appears that in the Final Neolithic *Vicia ervilia* seems to dominate the assemblages in frequency of occurrence as well as concentration values (Figs 1.8, 1.11). This observation could reflect changes over time with more bitter vetch being grown, for reasons that may be related to changing agricultural practices or a need for fodder (see below and Valamoti 2023). In contrast to the Central European LBK sites, pea is the least represented of the four pulses in the Greek assemblages studied (Figs 1.11, 1.14). Surprisingly chickpeas (*Cicer arietinum* L.) are totally absent until now, although they are present in the Balkan area and Anatolia.

1.8 Discussion

Using *ArboDat* as an analytical tool to explore a large body of data from northern Greece has proved very instructive for its potential and also the difficulties in analysing archaeobotanical data in order to discover crop choices and the possible reasons underlying them. It has been suggested, for example, that the varied assortment of cereal crops grown at different Neolithic sites in northern Greece may reflect cultural choices connecting these communities to their distant ancestors who brought agriculture to the area (Valamoti 2004). This observation is based on the predominance of einkorn at several Late Neolithic sites with less emmer (but with some exceptions), and is supported by results from the Bulgarian Neolithic and the LBK area as well (see references above). Our analysis presented here poses an important question: which line of evidence are we to consider as more reliably reflecting crop choice between different sites? The figures we have obtained in our analysis of northern Greek data call for caution, as the predominance of a certain glume wheat depends on whether the grain or chaff are being compared and on whether the analysis takes into consideration absolute numbers (Figs 1.12, 1.13; Table 1.1), concentration values (Figs 1.9, 1.10; Table 1.3) or ubiquity (Figs 1.6, 1.7; Table 1.2).

It is of interest to note that although more einkorn or emmer occur in individual samples from some sites, the frequencies of these two glume wheats are more or less evenly balanced when ubiquity is considered (Figs 1.6, 1.7; Tables 1.1, 1.2). Moreover, although free-threshing wheat has never been identified in a pure dense concentration (mass find), and thus has been considered as being most probably a weedy contaminant in other cereal crops (Valamoti 2004), it is persistently present at some sites. It is possible that future investigations may reveal northern Greek sites where free-threshing wheat was more than a crop contaminant. The case of Anarghiri III in western Macedonia, currently under study by Stavroula Michou indeed provides such an example (Fig. 1.6). Cultural preferences for free-threshing wheat have been considered as being responsible for the occurrence of naked wheat at some Bulgarian sites, interpreted as the outcome of contacts with Anatolia (Marinova and Valamoti 2014).

Cultural preferences also might be responsible for the late appearance of barley and free-threshing wheat at the end of the LBK period (around 5000/4900 cal BC), as opposed to the two glume wheats, emmer and einkorn, which were grown from the earliest LBK phase onwards. This is surprising, as the LBK arose in north-western Hungary, and the first farming communities in southern and eastern Hungary, belonging to preceding Early Neolithic cultural groups, grew naked wheat and barley from their very beginning (Kreuz 2012; Kreuz et al 2020).

Lathyrus sativus/cicera and *Vicia ervilia* are very common in the Greek Neolithic (Figs 1.8, 1.11, 1.14) as well as that of Bulgaria (Kreuz and Marinova 2017; Marinova and Valamoti 2014). Further north, however, in the LBK of Central Europe, these two species are absent, apparently a choice that may be related to their need for special preparation to avoid ill effects (below). For this reason lentil and especially pea were mainly grown to feed Neolithic communities within the LBK area (Kreuz and Marinova 2017). A serious disadvantage of *Lathyrus sativus/cicera* and *Vicia ervilia* as crops is their poisonous seed coat (testa), which has to be removed to render the seeds suitable for consumption by humans and animals, causing extra work for plant food processing. The fact that these pulses were still grown in the Balkan area, Greece, Anatolia and Southwest Asia was probably due to their low requirements for soil fertility, field work and especially their tolerance of periods of drought (Kreuz 2015c; Kreuz and Marinova 2017). This hardiness made them attractive for the Neolithic farmers in areas with winter rain and hot summers, but not so for other parts of Europe such as Hungary. Although experimental work has shown that these pulses can grow well in these northern regions, they were left out of the range of crops grown by the early farmers as they spread to the north (Kreuz 2015c; Kreuz and Marinova 2017; Kreuz et al 2020). For better understanding the role of climate and environmental parameters or other possible reasons underlying such a pattern, an integrated systematic study of crops and their associated weeds would be interesting (Kreuz and Schäfer 2011).

Another difference between the data from northern Greece and results obtained from areas further north is the absence of chickpea (*Cicer arietinum* L.) from Greece. This is an unexpected result which perhaps distinguishes the northern Greek Neolithic from the Balkan area (Filipović 2014; Filipović and Obradović 2013; Kroll 1983, 1991; Marinova 2011). The same applies to Celtic bean (*Vicia faba*) which, in contrast to Southwest Asia, is absent from the Greek assemblages as well, except for a few seed fragments with insecure identifications (cf.) from Late Neolithic Makriyalos (Valamoti 2004). This evidence from the north Aegean suggests that some crops were left out of the Neolithic Southwest Asian crop package as it moved northwards to Central Europe. The variable patterns detected through the examination of both cereal and pulse crop records from Neolithic northern Greece, compared to those from regions further north across the Balkans through to Central Europe, reveal the complex interplay between cultural and environmental factors for crop choices and their resulting food products.

Taking other crops into consideration such as cultivated flax (*Linum usitatissimum* L.) and opium poppy (*Papaver somniferum* L.), flax is quite frequent in northern Greece (Valamoti 2011), yet opium poppy is almost absent. The few seeds from Late Neolithic Makriyalos and Final Neolithic Mandalo need to be dated to be reliable. It is possible that connections intensified during the course of the Late Neolithic and the Bronze Age along the river valleys from the north Aegean further northwards to the Balkans and Central Europe and opium poppy later spread southwards along such routes after its long geographical journey from the western Mediterranean area (first stated by Bakels 1982; see also Kreuz 2012, 83; Valamoti 2007, 286-287). Such communication networks certainly operated and contributed to the spread of the cereal and pulse crops northwards, including *T. timopheevii*, which, as already mentioned above, has been found from Serbia, but rarely and as isolated finds from the Central European LBK.

The choice and timing of the introduction of the various crops into different areas during the course of the Neolithic are important aspects which deserve more detailed consideration and data from adequately retrieved archaeobotanical material. The choice or rejection of crops, like certain pulses, oil plants or free-threshing cereals together with the rarity of *T. timopheevii* from LBK sites in Central Europe, calls for a more detailed analysis in the future, integrating more data from a wider geographical area, ranging from the Aegean and the western Mediterranean to Central Europe, and comparing crop choices to archaeological finds relating to food preparation such as grinding tools, cooking pots and cooking facilities.

The Neolithic cereal and pulse spectra from northern Greece do not include common millet (*Panicum miliaceum* L.), spelt wheat (*Triticum spelta* L.) and Celtic bean (*Vicia faba* L.), which appear in different periods and sites during the Bronze Age (Valamoti 2007, 2023). Besides adding variety to the food available in the region, the new crops which appeared in the Bronze Age raise further questions about the cultural, economic and environmental parameters involved in their introduction to southeastern Europe and spread further north (Valamoti 2016, 2023). Such approaches could be very instructive, as is the case for example with the much later appearance of common millet (*Panicum miliaceum*) at the end of the 3rd mill in northern Greece and a new cooking facility that corresponds to a fusion of a hearth and a pot called *pyraunos* (Valamoti 2016, 2023).

Certainly, studying a large data set of archaeobotanical data from a wide area will allow a finer resolution in detecting the reasons underlying crop choices, in particular those of the cereals and pulses that were probably the staples in prehistoric Europe. The factors underlying such choices were most likely the outcome of a complex interplay between culture and nature. Ways of using food and established traditions even at a site level would have led to a range of crop choices where the limiting factors might have ranged from summer drought or food taboos to preferences related to ancestral choices.

1.9 Conclusion and perspectives

As discussed above, the application of *ArboDat* to a large data set from the Neolithic of northern Greece as well as other parts of Europe offers a means to map the plant food resources used over time and in various regions. Having this as a basis, other aspects to be explored within PlantCult concern the recognition of specific foodstuffs prepared with the available plant food ingredients that have been identified by the archaeobotanical study of plant remains. Moving to this level of analysis is much more complicated, as the archaeological remains of prepared food are normally only found as fragments of the former meals (Fig. 1.5). In the PlantCult project, electron microscope (SEM) images have been used and are likely to reveal more about the steps of food preparation, reflecting a tiny portion of all the prepared food that has been retrieved archaeologically (Valamoti et al 2019). A systematic experimental, ethnographic and archaeological reference collection of charred ancient plant food remains and a database designed to accommodate this are currently being assembled in PlantCult (Valamoti et al 2021). This may ultimately lead to regional syntheses not only of specific plant food ingredients but also on aspects of food preparation, once material related to the whole sequence, from ingredients leading to a finished dish, has been assembled from a large number of archaeological sites.

Fig. 1.15 Five cereals and many ways of preparing them for food existed in prehistoric northern Greece reflecting the interplay between nature and culture (Photo: S. M. Valamoti).

The existing different lines of evidence for plant food preparation are made available through the use of *ArboDat* in combination with finds of tools used for grinding, crushing and cooking the ingredients. These data provide a more complete view of past food preparation, connecting the ingredients with the equipment used and the resulting food product (Fig. 1.15). Such a combined use of evidence provides a valuable tool to explore a very important aspect of past food cultures. Through that access, past food preference "borders" and zones of interaction different to those of today can be observed.

If we were to compare our observations on food differences between the Aegean and Central Europe we could conclude that for a Neolithic Central European, a dish of grass pea would have been an exotic taste, while for a Neolithic Aegean dweller, a poppy-seed cake would have been a surprising taste. The spread of *Lathyrus sativus/cicera* and *Vicia ervilia* as crops to Central Europe as well as that of opium poppy (*Papaver somniferum*) to the Balkan area and further south possibly did not occur before the Bronze Age. One might seek the reasons underlying this later exchange of new crops in networks of intensive contact between the north Aegean and Central Europe during that period, in connection with the beginning of metalworking within the latter area (Kreuz 2016b; Kreuz and Feth 2021; Valamoti 2007; 2023). Future exploration of large scale changes of crops in space and time with the aid of tools such as *ArboDat* will reveal further food traditions and introductions in prehistoric Europe. It is only through a large body of well retrieved and archived data that the fascinating interaction between prehistoric farming communities of Europe and their environment can begin to be disentangled, so offering a narrative about ancient peoples and their crops, identity, culture and environment.

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Chapter 2

Cooking with cereals in the Early Bronze Age kitchens of Archondiko Giannitson (northern Greece): an archaeobotanical investigation of phase IV (2135-2020 cal BC)

Soultana Maria Valamoti, Chryssa Petridou

Abstract

This paper examines the Early Bronze Age archaeobotanical assemblage from the phase IV buildings from the site of Archondiko Giannitson, a tell site in northern Greece (western Macedonia). Special emphasis of the paper is on cereal species and cereal food products. The material retrieved by flotation comprises 110 samples (with a volume of over 3000 litres) and a total of 144,168 macrobotanical remains. A wide range of cereal crops, oil plants and plants harvested from the wild have been identified in pure, rich concentrations, due to a fire event which destroyed the settlement. Glume wheats at the site include einkorn (*Triticum monococcum* L.), emmer (*T. dicoccum* Schübl.), "new glume wheat"-(*T. timopheevii* Zhuk.) type and spelt wheat (*Triticum spelta* L.). Free-threshing cereals were found stored in some of the houses and include free-threshing wheat (durum/bread wheat, *Triticum durum/turgidum/aestivum*) and hulled barley (*Hordeum vulgare*). Of these, the most prominent cereals in the assemblage are einkorn, free-threshing wheat and barley. Besides cereals, linseed (*Linum usitatissimum* L.) is encountered in several houses as well as a rich concentration of *Lallemantia* sp., a plant of the mint family (Lamiaceae). In addition to a great variety of stored products, phase IV at Archondiko, has revealed a wealth of remains that correspond to processed cereal food remains. These include cereal fragments, lumps of cereal fragments and sprouted cereal grain. Based on the spatial distribution of grain and seed concentrations as well as concentrations of processed cereals across the different buildings of phase IV we show the wide variety of stored crops and cereal-based food products prepared at Archondiko. The investigation of the details of cereal food preparation at Archondiko form part of the goals of the ERC funded project PlantCult.

Keywords: *Early Bronze Age, Greece, burnt layer, cereals, cereal foodstuffs, beer, charred remains*

2.1 Introduction and aims of the paper

Archondiko Giannitson is a tell settlement with multiple habitation phases in the region of western Macedonia, northern Greece (Fig. 2.1; Papaefthymiou-Papanthimou and Pilali-Papasteriou 1995). Systematic excavations conducted by the Aristotle University

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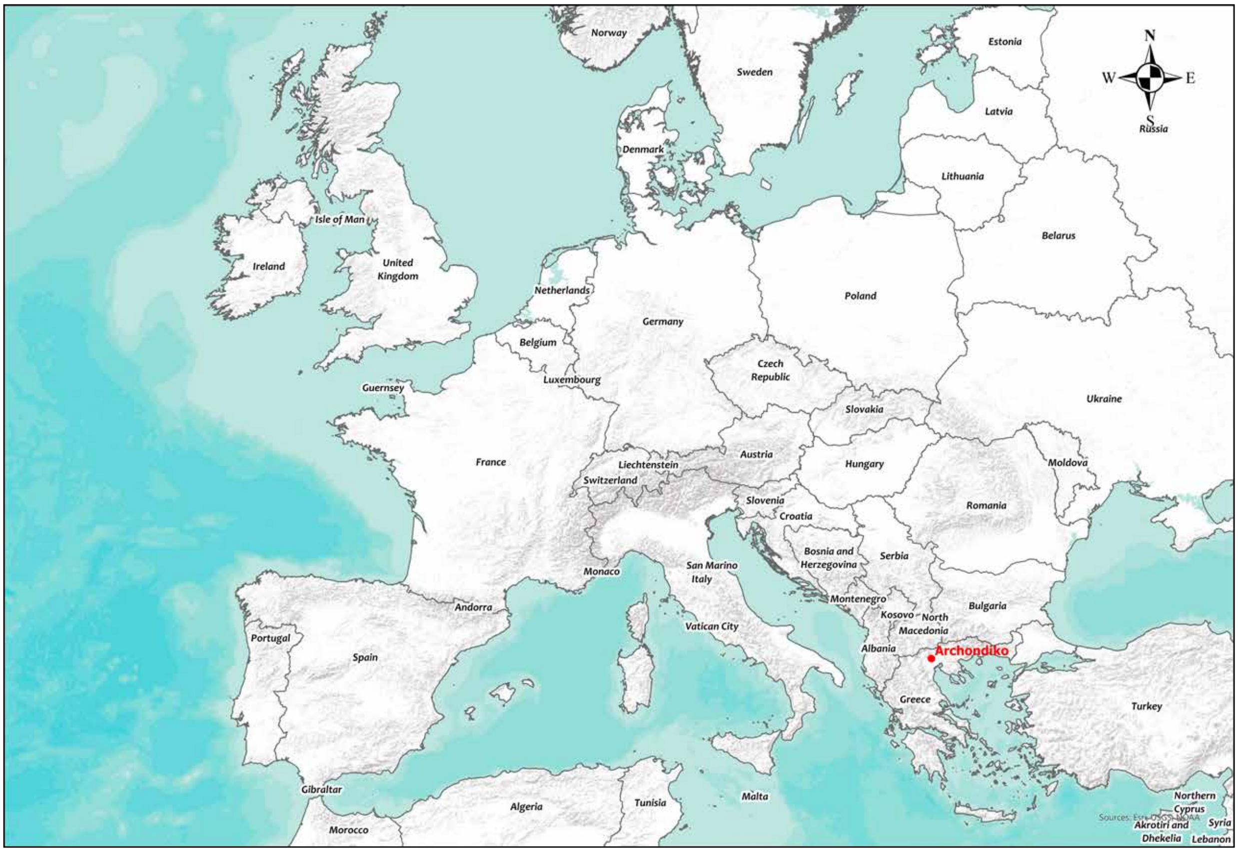


Fig. 2.1 Map of Europe showing the location of Archondiko Giannitson in northern Greece.

Fig. 2.2 Clay thermal structures from Archondiko phase IV (after Papadopoulou and Maniatis 2013, fig. 1).

of Thessaloniki between 1992 – present, have revealed three habitation phases dated to the Early Bronze Age (approximately 2135-1890 BC) and one dated to the Late Bronze Age (1516-1414 BC). The architectural remains and household equipment are characterized by an excellent state of preservation due to their destruction by fire, thus preserving a multitude of clay structures (Papadopoulou 2010; Papadopoulou and Prévost- Dermarkar 2007) and vessels (Fig. 2.2; Papanthimou et al 2013). The preliminary study of the rich archaeobotanical material from the site has revealed a great variety of plant species which were probably used in the inhabitants' diet (Valamoti et al 2008a), as well as indications of cereal processing in order to produce foodstuffs similar to bulgur, *trachanas* and beer (Valamoti 2002, 2018; Valamoti et al 2008b). The present paper is the first systematic study of cereals from Archondiko's EBA phase IV with the emphasis on their processing stage. The aim of the analysis is to understand the contribution of cereals both to the everyday diet of the Archondiko inhabitants and the ways they were transformed into food and perhaps alcoholic drinks. The study of the Archondiko plant food remains forms a core line of investigation in the context of ERC project PlantCult. The project has aimed to investigate the plant food cultures of ancient Europe, from the Aegean to Central Europe during the Neolithic and the Bronze Age (e.g. Valamoti et al 2017) integrating various lines of evidence besides charred plant remains such as grinding and pounding tools, cooking vessels and thermal installations as well as textual evidence for later periods. Archondiko offers a unique opportunity for a contextual approach of cereal based foodstuffs and an exploration of the scale of food preparation, in particular food preparation for special occasions on which great quantities of food were consumed.

2.2 Materials and methods

The archaeobotanical material examined here comes from the archaeological deposits of phase IV of the site, dated to the end of the Early Bronze Age with absolute dates that place it at 2135-2020 BC (Papadopoulou et al 2010). The material consists of 322 soil samples with a total volume of more than 4000 litres, from which rich carbonized archaeobotanical material was retrieved. The samples come from seven habitation units densely spaced, with buildings positioned parallel to each other, and some of them separated with partition walls (Fig. 2.3; see also Papanthimou et al 2013; Papaefthymiou-Papanthimou and Papadopoulou 2014).

During the excavation periods from 1993 to 2008 more than 450 soil samples were collected from the deposits of phase IV. The samples were processed by flotation at the Archaeological Museum of Pella (French 1971), and from them a rich carbonized archaeobotanical assemblage was recovered. The smallest mesh-size used was 300 microns. Heavy residues were kept but here only the material retrieved from the flots is presented. These samples are examined in the present study, with the emphasis on cereals. The samples come from the buildings A, B, C, D, E, ST and Z (Fig. 2.3), and represent a number of clay structures, such as storage facilities, platforms, ovens and hearths, as well as clay vessels and postholes (Papadopoulou 2010; Papaefthymiou-Papanthimou and Papadopoulou 2014) (see Fig. 2.2 above). In total, 110 archaeobotanical samples corresponding to more than 3000 litres of soil were selected for detailed study, after a scan which excluded samples that were relatively poor in remains (samples with <100 plant parts) and focused on 96 samples with more than 100 archaeobotanical parts per sample, and 14 more samples which contained processed cereal foodstuffs. The 22 samples that have been examined for archaeobotanical material from house Z are low in plant parts and thus this building has not been included in the present analysis. The identification of plant species and genera was conducted at the Laboratory for Interdisciplinary Research in Archaeology (LIRA) of the Department of Archaeology of the Aristotle University of Thessaloniki, with the aid of the reference collection and drawings available in the bibliography. The nomenclature of scientific plant name follows Flora Europaea (Tutin et al 1964-1980) and Zohary et al (2012). The identification of the processed remains presented here is in progress and in parallel with the study of the experimental reference material from various categories of processed cereal foodstuffs, research which is being conducted in the framework of the ERC funded PlantCult research project (http://plantcult.web.auth.gr/en/). The laboratory stage of the study of the assemblage of botanical macro-remains from phase IV has been concluded. Specific food preparations from Archondiko have been examined with the aid of Scanning Electron Microscopy (SEM) in order to observe the specific structures of the food remains that might be indicative of the processing steps leading to their preparation (see for example Valamoti et al 2019, 2021). Scanning electron analysis and microphotography were performed at the Department of Geology using a JEOL JSM- 840A and a JEOL JSM-6390LV. Samples were coated with carbon – average thickness of 200 Å – using a vacuum evaporator JEOL-4X. The particular characteristics of the Archondiko fragments, potentially indicative of mechanical and thermal processing with or without the presence of liquids, is the object of an ongoing study in the framework of the PlantCult research project (funded by the ERC), with the aid of a series of experiments (cf. Sereti et al 2021) which shall contribute to the understanding of the stages of cereal processing for the preparation of specific foodstuffs during prehistoric times.

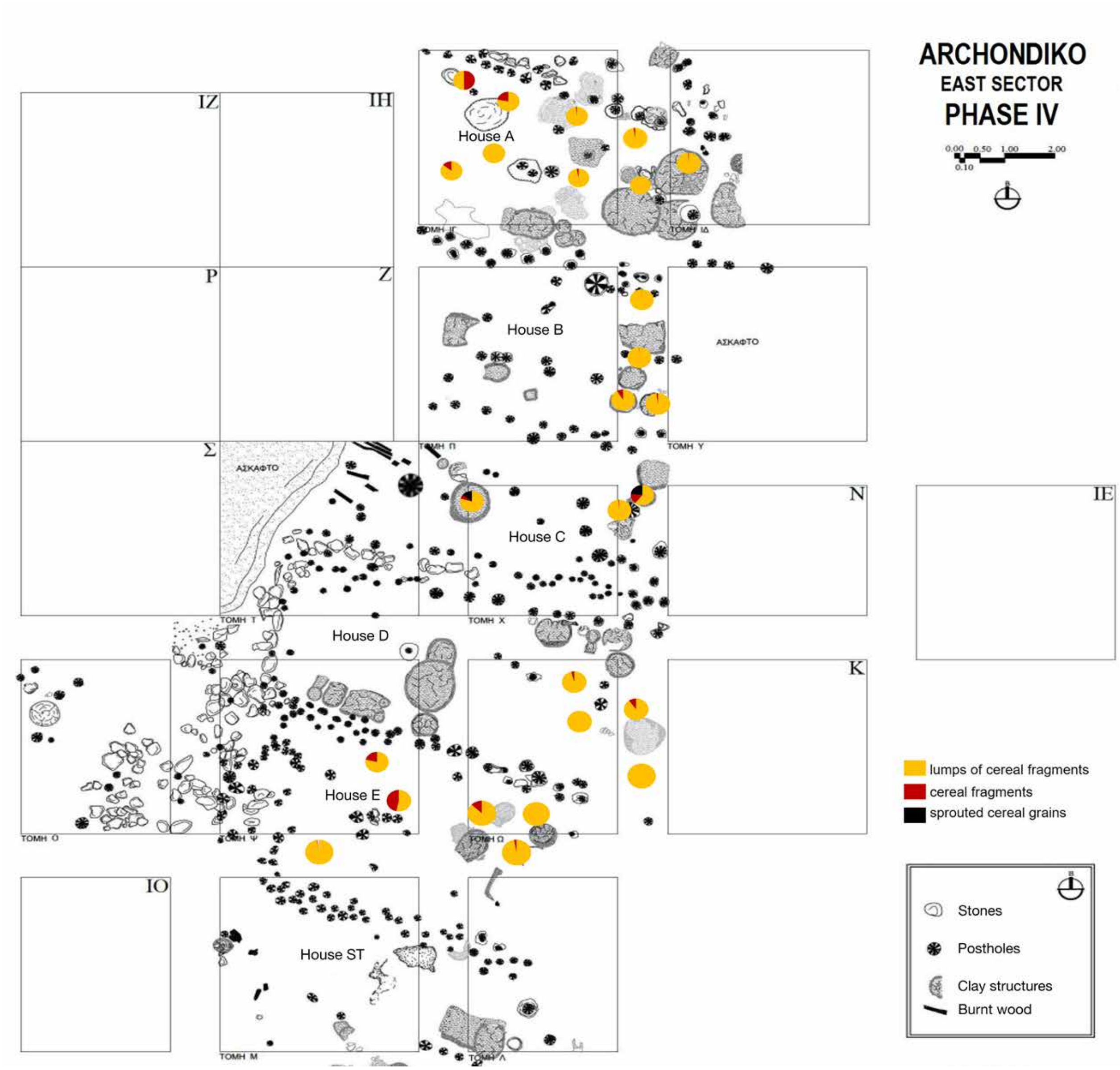


Fig. 2.3 Spatial distribution of cereal fragments (red), lumps (yellow) and sprouted cereal grains (black) from phase IV of Archondiko Giannitson (relative proportions based on volume).

2.3 Results

2.3.1 General results

The preliminary examination of the material from the buildings of phase IV (Valamoti et al 2008a; Papanthimou et al 2013), as well as the ongoing research, have yielded an array of information as to the species of the identified plants (Table 2.1). These include many species of cereals, pulses, oil plants as well as wild fruits and nuts, such as acorns. Cereals appear to be most prevalent among the archaeobotanical material (Fig. 2.4).

In the buildings of Archondiko concentrations of oil plants have also been discovered such as linseed (*Linum usitatissimum* L.) and *Lallemantia* sp. (Jones and Valamoti 2005) (Table 2.1). Linseed has been found in different buildings, thus conveying its importance for the settlement's inhabitants (Valamoti 2011a). The presence of *Lallemantia* is also a frequent occurrence (Jones and Valamoti 2005) in various areas and in small percentages, with only one rich and pure concentration located in building D. Pulses, although present in the samples, have almost never been found in rich and pure concentrations. Equally restricted is the presence of fruits and nuts harvested from the wild, with the exception of acorns which are abundant in samples from some buildings (e.g. building D).

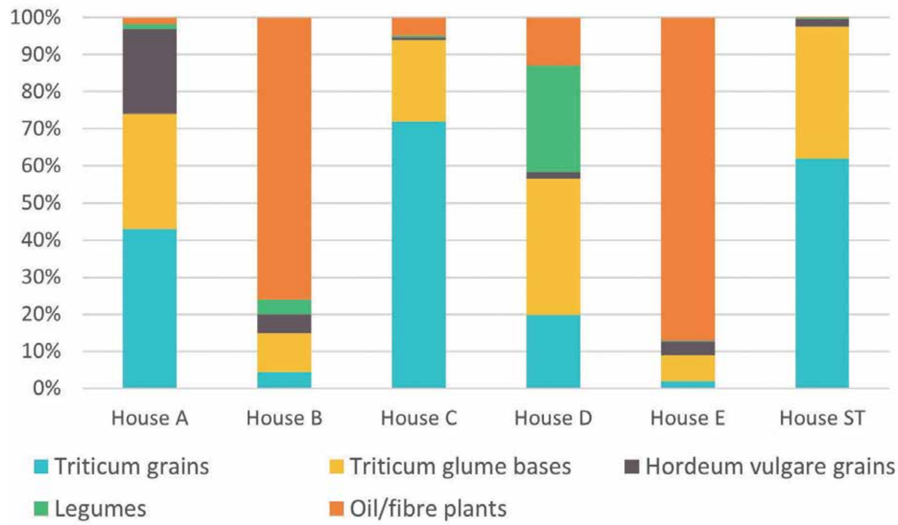


Fig. 2.4 Relative proportion of crop groups/types and fruits/nuts per house/building (all samples with >100 plant remains included).

Table 2.1 The plant species identified in the archaeobotanical remains of phase IV.

Cereals	Legumes/Pulses	Oil plants	Fruits and nuts
T. monococcum L.	*Lens* sp.	*Linum usitatissimum* L.	*Quercus* sp.
T. dicoccum Schübl	*Lathyrus sativus* L.	*Lallemantia* sp.	*Vitis vivifera* L.
T. spelta L.	*Vicia ervilia* (*L.*) Willd.		*Ficus carica* L.
T. *timopheevii* Zhuk.	*Vicia faba* L.		*Rubus fruticosus* agg.
T. turgidum/aestivum			*Sambucus* sp.
Hordeum vulgare.			*Cornus mas* L.
			Prunus sp.

Table 2.2 Archondiko phase IV: number of samples included in the current analysis and quantity of archaeobotanical remains per house.

	House A	House B	House C	House D	House E	House ST
Number of soil samples	41	5	19	12	10	10
Number of plant parts	46117	232	25576	1958	3993	36160
Processed cereal remains, volume (ml)	940	27	58	85	307	

In the present paper we present only the samples where cereals account for at least 40% of the total archaeobotanical remains (Table 2.2). The percentages of the various cereal species, as well as their plant parts, are examined, with the aim of determining the stored concentrations of cereal grains as well as their processing stage. Buildings A and ST are presented in more detail, as the presence of cereals there is impressive. Lastly, the spatial distribution of probable cereal-based foodstuffs is examined, such as cereal grains, sprouted grains, cereal fragments, lumps of fragments, unidentified lumps; their distribution in the excavated area is shown on Fig. 2.3. Through this spatial analysis we aim to achieve a better understanding of the particular dietary remains found at Archondiko and which reveal, as we shall see below, an intriguing cuisine with great culinary potential.

Fig. 2.5 Einkorn wheat grains from Archondiko, phase IV.

Fig. 2.6 Bread/durum wheat grains from Archondiko, phase IV.

Fig. 2.7 Barley grains from Archondiko, phase IV.

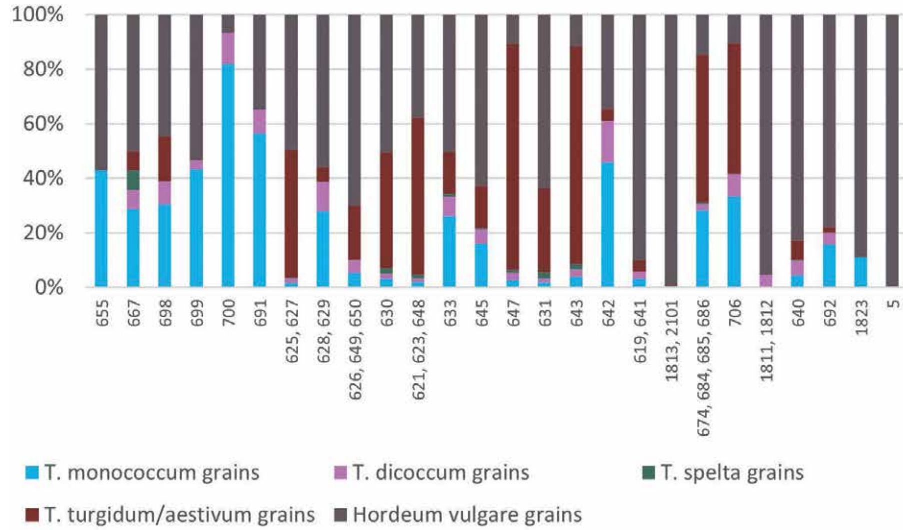


Fig. 2.8 Relative proportions of cereal species based on grains, samples from House A.

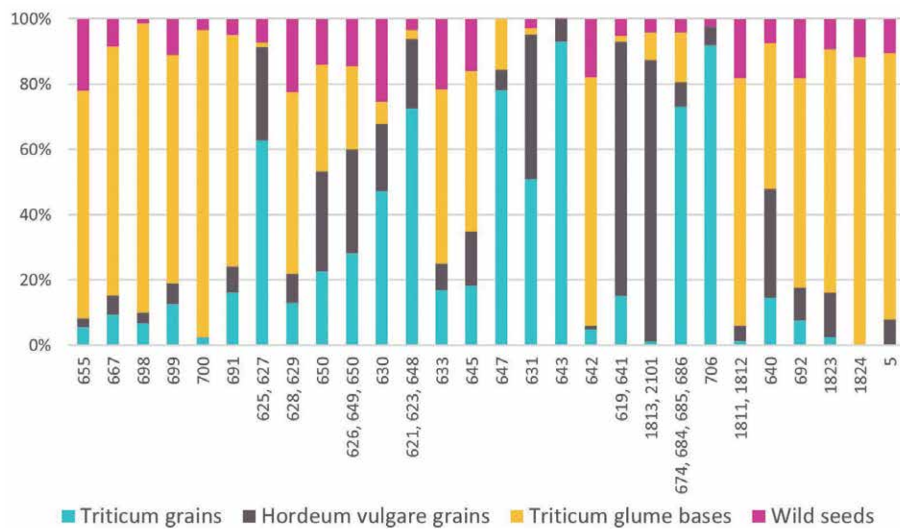
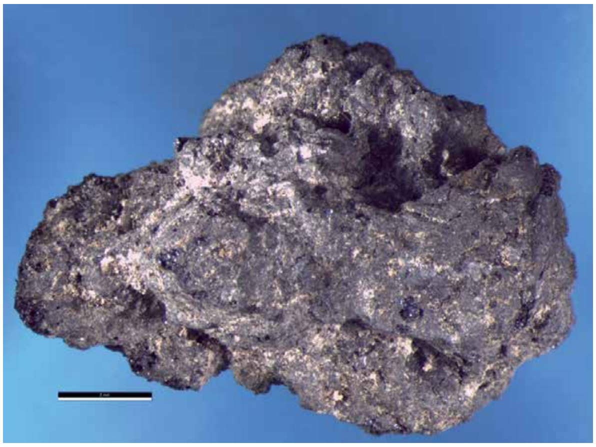


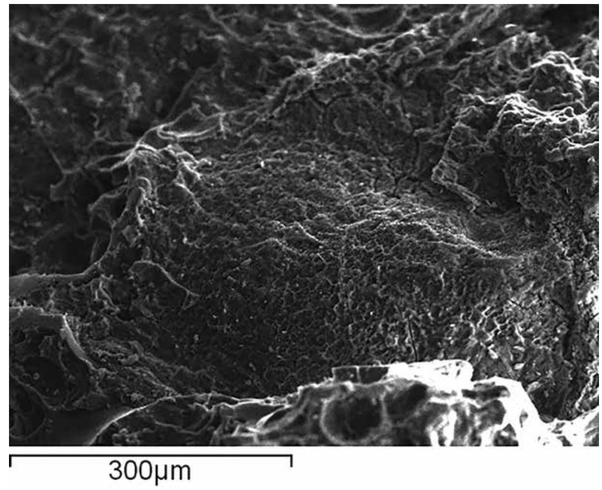
Fig. 2.9 Relative proportions of grains and glumes from hulled wheats, samples from House A.

2.3.2 Results of house A

Forty-one samples come from this house, which yielded 46,117 plant parts in total. Regarding the cereals, the identified species are the following: einkorn wheat (*Triticum monococcum* L., Fig. 2.5), emmer wheat (*T. dicocccum* Schübl.), spelt wheat (*T. spelta*), free-threshing wheat (*T. aestivum/turgidum*), and barley (*Hordeum vulgare*). In this building, cereal grains dominate, especially of naked wheat and barley (Figs 2.6, 2.7), while in certain samples glumes and weeds are prevalent, indicating the presence of the by-product of cleaning hulled wheats from glumes (Figs 2.8, 2.9). As to the spatial distribution of cereal species concentrations, there appears to be different concentrations of barley grain and naked wheat, which were probably stored separately in specific areas of the house and they potentially correspond to structures or vessels.

Apart from the whole grains, throughout House A lumps of ground cereals were found (Fig. 2.10) in different quantities, while in certain areas significant quantities of cereal fragments were identified (Fig. 2.11). Regarding their spatial distribution, the samples richer in dietary remains from processed cereals are concentrated towards the eastern part of House A (Fig. 2.3), where there is also a cluster of clay structures. A second concentration of processed cereals is located at the central part of the building, towards the northern wall, an area in which a great number of vessels has been found. We do not observe the presence of shiny fragments in the lumps, or the melted appearance that resembles the experimental specimens of bulgur and other cereal fragments charred wet (Valamoti et al. 2021), which suggests that these were probably stored and not in some process of brewing at the time of the destruction of the building by fire. The research in the framework of the ERC funded project PlantCult aims





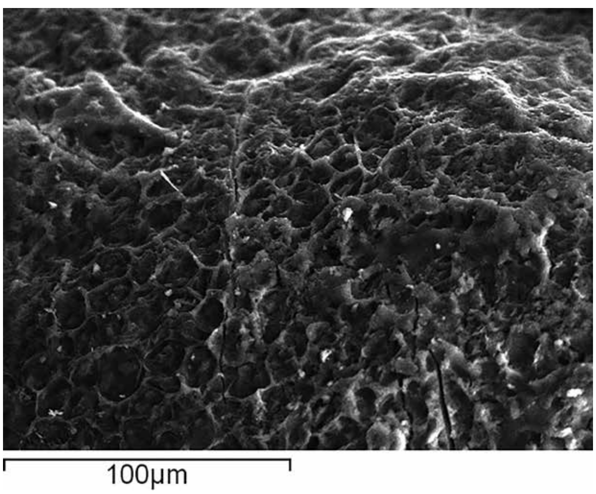


Fig. 2.10 Lump of ground cereals from House A. a stereoscope photograph; b SEM image; c detail of b, pericarp of cereal grain, aleurone layer.

Fig. 2.11 Ground cereal fragments from House A.

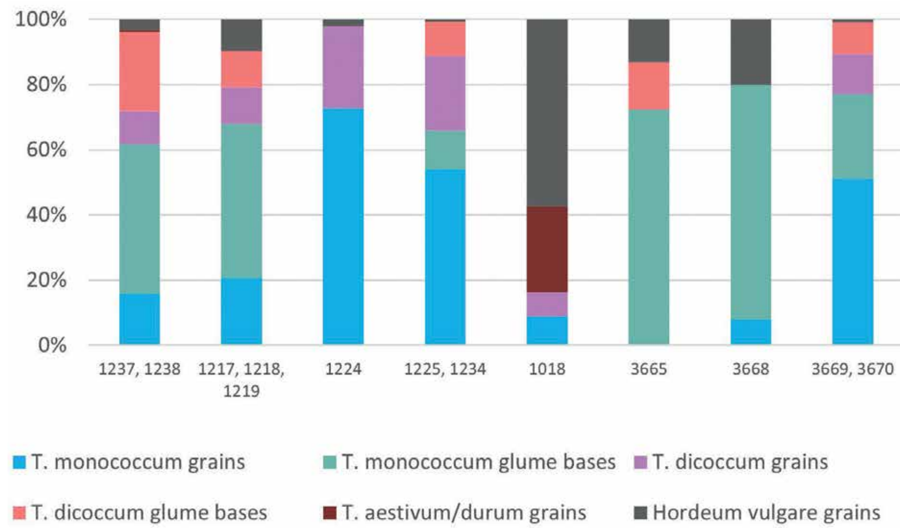


Fig. 2.12 Relative proportions of grains and glumes of hulled wheats, samples from House C.

to investigate this possibility with the aid of experimental material. In this case, one would expect specific use-wear traces in the interior of the vessels, of which there is very limited evidence from Archondiko for the moment (trench M, house ST, vessel AR8, Dimoula et al 2022).

2.3.3 Results of House B

The 15 samples from House B are in their majority poor. Of these, however, five samples are rich and comprise 232 plant parts as well as dietary remains, which are mostly in the form of lumps containing cereals (for their location see Fig. 2.3). Although the number of findings is rather small, in the samples of House B a variety of cereals were identified, including einkorn, emmer and naked wheat as well as barley. These finds come from the eastern part of the building, from an area where a cluster of clay structures is located.

2.3.4 Results of House C

From House C, 19 rich samples were recovered which have yielded 25,567 plant remains. Although the species repertoire is not different to that of House A, here the prevalence of hulled wheats, einkorn and emmer, is noticeable (Fig. 2.12). A rich concentration of einkorn and emmer wheat is located at approximately the center of the building. The presence of grains with their glumes here suggests the storage of cereal crops in the form of spikelets. In the same area a small concentration was found, containing grains of einkorn and emmer wheat, cleaned from their glumes.

The archaeobotanical assemblage of House C is of particular interest. Here, the remains of processed cereals are located mostly in proximity to clay structures (Fig. 2.3): ground cereals, fragments of ground cereals consolidated in lumps, and two concentrations of sprouted cereal grains, probably wheat (Fig. 2.13), which come from the interior of two clay structures. The larger of these concentrations, consisting of 62 sprouted grains, was found in the interior of a clay structure

Fig. 2.13 Sprouted wheat grains from flotation sample NK1026, clay structure 89.

(clay structure 89 as discussed in Papadopoulou 2010), together with a small number of ground cereal fragments and cereal lumps. This structure lies towards the eastern part of the building (Fig. 2.2) and poor preservation does not allow for an identification. It can be attributed to either two separate storage facilities or one multi-room thermal structure, a characteristic type for Archondiko. The structure to the west (clay structure 16 as discussed in Papadopoulou 2010), where the smallest of the concentrations was found, has been interpreted as a storage structure.

2.3.5 Results of House D

The 12 samples from House D included in the analysis have yielded 1958 plant remains, in which barley and four species of wheat (einkorn, emmer, spelt and naked wheat) have been identified. In the samples containing cereal remains the glumes of hulled wheat are most prevalent,

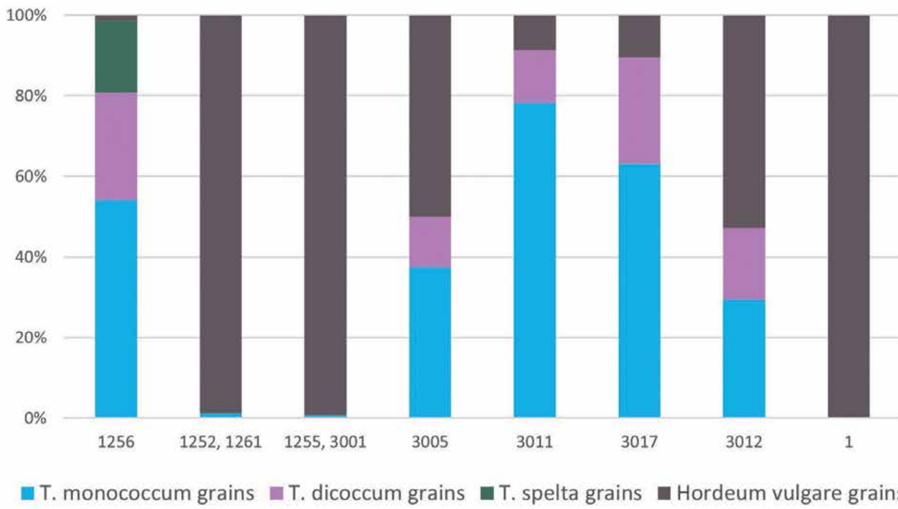


Fig. 2.14 The ratio of cereal species based on the grains in the samples from House ST.

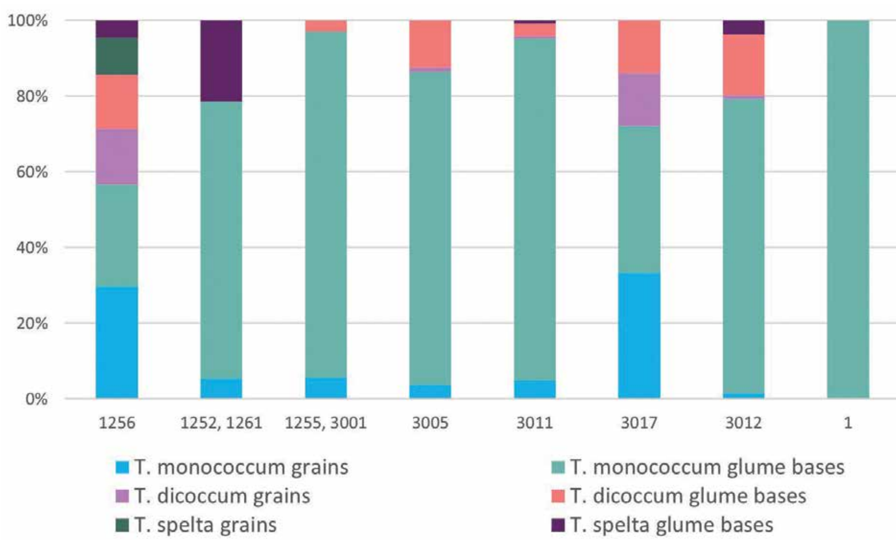


Fig. 2.15 Relative proportions of grains and glumes of hulled wheats, samples from House ST.

representing mainly the by-products of the processing for cleaning the grain from glumes. The archaeobotanical assemblage of House D also includes dietary remains found mostly in the form of lumps from ground cereals and also ground cereal fragments, which are found mainly in relation to clay structures or vessels (Fig. 2.3).

2.3.6 Results of House E

From House E, 10 samples were examined, which have yielded 3993 plant remains. Regarding the cereal grains, barley dominates these samples. The wheat remains are mostly glumes, which indicate that einkorn wheat was the preferred species. The archaeobotanical assemblage of this building includes remains of processed cereals, which are found as lumps with ground grains, often located around clay structures.

2.3.7 Results of House ST

From House ST, 12 samples are examined, containing 36,160 plant remains. The cereal species identified are einkorn, emmer, spelt and new type wheat, bread/durum wheat and barley. Here, just as in House C, the prevalent species are einkorn, emmer and spelt, i.e. three species of hulled wheat (Figs 2.14, 2.15). The analysis showed that many samples are dominated by glumes together with seeds of wild plants, suggesting the presence of by-products of processing hulled wheats. However, two concentrations of stored cereals were found: a barley concentration and a particularly rich concentration of hulled wheat spikelets (einkorn, emmer and spelt), with einkorn being the more prevalent. As to the indications for the presence of processed cereals, despite the fact that cereal lumps are found scattered in many of the samples, these are always in very small quantities.

2.4 Discussion: Storage and processing of cereals and other plants at Archondiko during phase IV of the settlement

Based on the preceding analysis, the buildings of phase IV of Archondiko served to store naked cereal grains, i.e. barley and naked wheat, spikelets of hulled cereals such as einkorn, emmer and spelt wheat, with some differentiation as to the most prevalent species in each building. In some buildings, especially in Houses A, D and E, by-products of the final stages of processing hulled cereals were also identified, i.e. glumes and weeds which had been removed leaving the grain clean for further processing for human consumption. These by-products were possibly stored for other uses. Apart from the stored cereal crops and the by-products of grain cleaning, processed cereal foodstuffs were also identified and include: (a) cereal fragments, (b) cereal fragment lumps, (c) lumps with porous material and fragments and (d) sprouted grains. The lumps of ground cereals, as well as the ground cereal grains, are mostly found in Houses A, D and E, where the largest volumes of such finds have been recorded; similar finds, however, are also observed in Houses B, C and ST in lower densities. These processed foodstuffs are spatially correlated (see Fig. 2.3) either with ceramic vessels, as in the case of building D, or with areas around clay structures (building B).

Previous studies have shown that these fragments were intentionally produced through grinding in prehistoric times (Valamoti 2002), however, in these initial studies it was not determined whether the fragments had been processed with water or other liquids (e.g. milk). The discovered lumps were most likely formed during prehistoric times rather than as a result of charring (Valamoti 2002; Valamoti et al 2008b).

The archaeological food remains from Archondiko will be compared to a series of experimental cereal food preparations that are being studied with the aid of Scanning Electron Microscopy; these have been generated with the use of a variety of flours produced by grinding cereal grains with replicas of Neolithic grinding tools, encountered at prehistoric Greek sites. It is possible that the cereal fragments were produced with the use of wooden mortars and pestles which have left no trace in the archaeological record: such tools would perhaps be better suited for grinding malt, which is particularly brittle and does not require great pressure.

To date, the research conducted on the archaeobotanical material of Archondiko has revealed the presence of lumps which were probably produced intentionally rather than inadvertently, given the fact that in Building A lump concentrations are found almost everywhere whereas the fragments only in one area (Fig. 2.3): if the lumps had been formed due to charring we would expect a combination of fragments and lumps everywhere in building A. Moreover, the unified exterior surfaces of several lumps indicate that they were probably created in this particular form, i.e. as lumps. Had they been generated by randomly consolidated fragments, then these would probably only partially preserve their exterior surface. However, the exploration of the effect of charring on cereal fragments is still ongoing in the framework of the ERC project PlantCult, as the consolidation of fragments due to charring conditions appears to vary depending on the presence of liquid and the grain size. Furthermore, lumps with an amorphous background and with fragments embedded in it have also been found (Valamoti et al 2019, fig. 12, 105), which also suggests intentional mixing and not the outcome of carbonization. The investigation of fragments is ongoing and the Archondiko fragments will be compared to a series of experimental specimens that will hopefully reveal the culinary processes that these fragments underwent (Valamoti et al 2021). The processed cereals found in Archondiko could correspond to a variety of foodstuffs, such as bulgur, *trachanas* (Valamoti 2011b) or even foodstuffs that are no longer produced, such as the ancient Greek *maza* (Micha-Lambaki 1984; Valamoti et al 2022).

The presence of sprouted grains is of particular interest, as it could suggest the production of malt. The presence of malt could be linked to the production of some form of prehistoric beer at the settlement (Valamoti 2018), however other foodstuffs could be produced with malt (Heiss et al 2020). The combined presence of lumps and fragments, as well as sprouted grains, if viewed in the context of the stages of beer production could correspond to the main ingredients providing the necessary sugars for alcoholic fermentation. These would have been ground grains, which were probably boiled, such as bulgur; ground sprouted grains; lumps of ground grains; along with flour and water which would have been fermented and then left to dry in the sun. This has also been proposed for the Late Bronze Age Tall Bazi site in Syria, based on experiments (Zarnkow et al 2011), while a mixture for beer production from ancient Egypt contained malt and cereal fragments (Samuel 1996). These ingredients could have been stored in vessels and/or clay structures and used throughout the year, according to the needs for quantities of a barley-based alcoholic beverage. Mixing them at temperatures around 70°C, with the use of the complex thermal structures, would be the basis for the production of such a beverage. The available evidence shows that the thermal processing at low temperatures which is necessary for brewing could have taken place in Archondiko's complex thermal structures, as, based on the experimental research by Papadopoulou (2010), in the second chamber of the structures the temperatures did not exceed 70°C. The research on the ingredients of the probable blend which was potentially converted into beer at Archondiko is underway in the framework of the ERC funded PlantCult research project.

Of course, the interest of the archaeobotanical material from phase IV of Archondiko is not restricted to the cereals and the probable foodstuffs these were used for. The total of the species that have come to light reveal a variety in crops as well as in the use of wild plants. The restricted presence of pulses at Archondiko, compared to cereals, may be related to the particular uses of these buildings, which were perhaps more specialized in processing vegetal materials that required treatment in the thermal structures that came to light in this particular area of the settlement, where the emphasis was probably on the storage and processing mainly of cereals and oil plants. Although the restricted presence of pulses in the specific area of the settlement could be random (e.g. crop failure in the year the buildings were burned), the fact that it is shared across almost all buildings and that pulses are not completely absent, indicates that pulses were cultivated at the settlement but the emphasis in the excavated buildings of phase IV was on other crops.

2.5 Conclusions

The archaeobotanical data we have examined in this paper, originating from the buildings of phase IV of Archondiko, when considered within their wider archaeological contextual associations, in particular the numerous thermal structures found in that phase, suggest that in this area of the settlement, a major culinary activity was the preparation of cereal-based foodstuffs; these had various forms and were stored as lumps of ground grains, ground malt and coarsely ground grains. These preparations could be used in various culinary recipes, one of which probably corresponds to some form of beer. This beverage could be produced both regularly, as a main dietary feature, and on special occasions, for example collective feasts, for which food and beverages would have to be produced for a great number of people. This has also been proposed for Argissa in Thessaly to the south, at the beginning of the Middle Bronze Age (a couple of hundred years later than Archondiko), based on the archaeobotanical data and the great number of cups that were recovered (Valamoti 2018, 620). Further synthesis of the data from Archondiko (architecture, pottery, thermal structures) should contribute to the exploration of this situation at the settlement at the end of the 3rd mill BC. To this end, the evidence of the spatial distribution of the numerous cups that have come to light from the phase IV buildings (Voulgari 2022) as well as evidence on the volume capacity of vessels which could have been used for the production of great quantities of food and beverages would be very enlightening.

In summary, the archaeobotanical research of Archondiko and phase IV in particular revealed a great variety in culinary practices based on cereals. Foodstuffs such as malt, bulgur, *trachanas* and beer could have been produced either for daily meals or for special occasions. The ongoing research conducted in the framework of PlantCult will contribute greatly to the better understanding of prehistoric cuisine in central Macedonia at the end of the 3rd mill BC.

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Chapter 3

Early viticulture in Neolithic and Bronze Age Greece: looking for the best traditional morphometric method to distinguish wild and domestic grape pips

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Abstract

The origins of viticulture and the domestication of the grapevine have been the subject of much research, notably on the basis of archaeobotanical remains. To identify wild and domesticated grapevines, analyses using various measurements have been performed on archaeological grape pips: length and breadth of the pip, length of the stalk, placement of the chalaza and indices/formulas involving these measurements. The performances of traditional methods based on size parameters, however, can vary largely when applied to modern cultivars. In addition, recent studies on the morphological distinction between wild and domesticated grape pips using size measurements and ratios highlighted the importance of the comparisons between the archaeological material to a representative reference collection of grape pips from diverse modern cultivars and wild populations. Given that different methods have been proposed for the distinction between wild and domesticated grape pips, some based on measurements and others on shape, this paper tests for the first time these methods based on a standardized collection of modern pips and compares their performances. The analyses were performed on a set of modern grape pips consisting of 34 cultivated varieties and 13 wild genotypes. Then, archaeological grape pips were compared to this set of modern reference material using the same measurements and methods. We used grape pips from three sites located in Northern and Southern Greece and dated from the Late Neolithic (ca 4500-4000 BC) to the Late Middle Bronze Age (ca 1700-1620 BC): Dikili Tash, Tzoungiza and P.O.T.A. Romanou. Our results show that shape analysis is the most efficient method to identify wild and domesticated grapevines, while traditional measurements are also highly reliable. The Stummer index represents the least accurate method. According to our analyses the archaeological pips from Late Neolithic and Early Bronze Age Greece belong to the wild morphotype. The Late Middle Bronze Age assemblage from Tzoungiza offers the first reliable evidence of morphologically domesticated grape pips, but the relative proportions of each type vary according to the methods used. This clearly shows how narratives about the origins of early viticulture and grapevine domestication may be influenced by the choice of identification method applied to archaeological grape pips.

Keywords: *grape domestication, traditional and modern morphometrics, archaeobotanical identification, form, shape and distance measurements*

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3.1 Introduction

Grapevine is one of the emblematic plants of the Mediterranean. It is considered to have been first domesticated in South-West Asia between 6000 and 3000 BC, but its domestication history is still debated. Indeed, evidence of early domestication from South-West Asia is limited, and new data question this hypothesis. The earliest finds of grapevine in archaeological contexts come from the region of the Dead Sea and date to the Pleistocene (Kislev et al 2004), and grape pips are found at several sites in the Near East during the Neolithic (Zohary et al 2012; Fuller and Stevens 2019), although large concentrations are not recorded before the 3rd mill BC (Miller 2008). In addition, the results from chemical analyses have been put forward to advocate the production of wine in the South-Caucasus as early as 6000 BC (McGovern 2003; McGovern et al 2017). But no evidence of grapevine domestication is currently available at such an early date and the onset of domestication in the area is still uncertain (Bouby et al 2021). Molecular studies confirm the existence of a main domestication centre in South-West Asia (Arroyo-Garcia et al 2006; Myles et al 2011; Bacilieri et al 2013; Riaz et al 2018) although the results of genetic research have been advanced to support the hypothesis of other centres of domestication (Grassi et al 2003; Arroyo-Garcia et al 2006). Parallel or secondary events (involving both local wild grapevine and varieties introduced from the putative primary centre) of domestication may have occurred anywhere in the area of natural distribution of the wild grapevine, from the Himalayas to Western Europe and around the Mediterranean basin (Levadoux 1956; Arnold et al 1998), including Greece (Logothetis 1970). Wild (*Vitis vinifera* subsp. *sylvestris*) and domesticated grapevine (*V. vinifera* subsp. *vinifera*) differ regarding their reproductive biology, and several phenotypic changes, including the morphology of the pips.

The question of grapevine domestication in Greece has recently been addressed (Pagnoux et al 2021). According to the dominant hypothesis, viticulture and wine making are related to the emergence of palatial civilizations in Crete and in the Peloponnese during the Bronze Age (Renfrew C 1972). However, evidence of wine making and grapevine management as early as the 5th mill BC (i.e. much earlier than the Late Bronze Age) in Northern Greece, far from Mycenaean Greece and Minoan Crete (Renfrew JM 1995; Valamoti 2009, 2015; Valamoti et al 2007, 2015, 2020; Pagnoux 2019; Pagnoux et al 2021) calls into question the origin of viticulture and its relation with the emergence of hierarchical societies in Prehistoric Greece (Valamoti 2017, 178). More recently, evidence from morphometric analyses, together with other indications offered by archaeobotanical and archaeological data, raises the hypothesis of a local domestication in the Aegean. A continuous use of local wild grapevines since the Late Neolithic would have led to the emergence of domesticated types during the Middle Bronze Age, and to the cultivation of various fully domesticated types from the Late Bronze Age onwards. Introduced cultivars from more Eastern regions may have played a role in the emergence of variability in the domesticated types in Greece (Valamoti et al 2020; Pagnoux et al 2021).

Archaebotanical inference of this domestication process is a longstanding challenge that has traditionally been based on the morphology of the grape pips. Measurements of specific features have long been used to distinguish wild and domesticated grapevine. The first index, proposed by Stummer was based on the size of the pips (Stummer 1911) and widely used by archaeobotanists. However, it was argued that this method presented a wide overlapping zone between the measurements of wild and domesticated pips and that several archaeological pips fall into this zone (e.g. Renfrew JM 1995). Furthermore, several works have pointed out the distortion induced by carbonisation and the discrepancy when comparing carbonised archaeological materials with non-carbonised modern ones (Logothetis 1970, 1974; Smith and Jones 1990). Both of these limitations led to a renewed search for measurements and indices that would both more accurately distinguish between domesticated and wild types and be less subject to the effects of deformation and size change caused by charring.

Morphometric analyses based on combinations of traditional measurements (size measurements including length, breadth, length of the stalk, position of the chalaza, thickness of the pips, etc) have been developed with the aim to better distinguish wild and domesticated grape pips (e.g. Kislev 1988; Di Vora and Castelletti 1995; Mangafa and Kotsakis 1996). Based on the analysis of modern pips from two Greek varieties and three wild populations, Mangafa and Kotsakis (1996) proposed four formulas allowing the distinction of wild and domesticated grapevine. Their work takes into account the influence of carbonisation on the measurements and the accuracy of the measurements including the difficulties in taking them. Their proposed formulas are designed to be applicable to any *Vitis vinifera* archaeological seed, which is a big advantage. However, some analyses of modern grape pips from France based on these formulas call into question their accuracy, especially regarding the identification of the domesticated grape pips, and suggest that the performance of the formulas in correctly identifying wild and domesticated pips should be tested on modern material from more numerous varieties, including specimens from other origins before their application to archaebotanical material (Bouby and Marinval 2001). The same remark could be addressed to the Stummer index, which was based on Austrian grapevines only.

Another attempt to focus on shape variability was the use of discrete measurements (as referred to above: length, breadth, length of the stalk and position of the chalaza) converted into log shape-ratios: each variable is divided by the geometric mean of all 4 variables and then log-transformed (Bouby et al 2013; Bouby 2014). This method would also be more directly applicable to distorted charred remains.

More recently, a method based on the outline analysis of the grape pips has been developed (Terral et al 2010). Geometric morphometrics allow the researcher to analyse the shape of the objects separately from their size thereby limiting the influence of environment and, more particularly, reducing biases related to the effect of charring. Moreover, geometric morphometrics are regarded to allow a better discrimination performance of wild and domesticated grapevine than methods based on the measurement of distances (Bouby et al 2006; Bouby 2014). It also offers information beyond the wild/domesticated distinction, through the identification of domesticated grape types (varieties, or groups of varieties) (Terral et al 2010; Pagnoux et al 2015, 2021; Bouby et al 2021).

In this paper, we benchmarked the different morphometric methods to compare their accuracy at discriminating between wild and domesticated types on a modern reference collection, more representative than the ones used by Mangafa and Kotsakis (1996) and Stummer (1911). This extended collection was used to train new linear discriminant analyses, based on shape and size descriptors separately, that were compared to Stummer index and to Mangafa and Kotsakis formulas. All these methods were then applied to grape pips from three archaeological sites dated to the period corresponding to the shift from morphologically wild to morphologically domesticated grapevine and to the beginning of the varietal diversification of grapevine in Greece, i.e. from Late/Final Neolithic (4500-4000 BC) to Late Middle Bronze Age (1700-1620 BC). Our chief aim was to test if the results of these different methods for determining wild versus domesticated pips were congruent or if their discrepancies may lead to different readings of the history of grapevine domestication in Greece.

3.2 Material and methods

We used a modern reference collection with 47 accessions, including 34 *Vitis vinifera* subsp. *vinifera* (domesticated grapevine) varieties and 13 *V. vinifera* subsp. *sylvestris* (wild grapevine) individuals (Table 3.1; Bonhomme et al 2020a). For each accession, 30 normally developed berries have been randomly collected from a single, fully ripe bunch, and a single pip was extracted from each berry. Domesticated material was sampled in the French central ampelographic collection (INRAE, Vassal-Montpellier

Domesticated varieties	L	LS	PCH	B
Aïn el Bouma	5.58 ± 0.41	1.94 ± 0.2	3.45 ± 0.25	3.52 ± 0.26
Alvarinho	5.2 ± 0.3	1.35 ± 0.21	2.68 ± 0.24	3.52 ± 0.2
Babeasca neagra	5.5 ± 0.27	1.44 ± 0.14	2.85 ± 0.21	3.72 ± 0.17
Barbera	6.77 ± 0.37	1.96 ± 0.16	3.62 ± 0.26	3.68 ± 0.22
Cabernet-Sauvignon	5.95 ± 0.24	1.8 ± 0.16	3.11 ± 0.18	3.6 ± 0.14
Carignan	6.93 ± 0.26	2.16 ± 0.2	3.9 ± 0.25	3.52 ± 0.21
Chaouch blanc	6.91 ± 0.37	1.75 ± 0.17	3.83 ± 0.34	4.12 ± 0.31
Chardonnay	5.35 ± 0.44	1.44 ± 0.24	3.1 ± 0.29	3.77 ± 0.3
Chasselas	5.93 ± 0.31	1.63 ± 0.22	3.06 ± 0.23	3.8 ± 0.26
Chevka	6.01 ± 0.32	1.49 ± 0.16	3.03 ± 0.18	3.72 ± 0.19
Cinsaut	5.99 ± 0.33	1.74 ± 0.18	3.38 ± 0.21	3.7 ± 0.22
Debina	7.02 ± 0.49	1.73 ± 0.2	3.7 ± 0.32	4.16 ± 0.27
Ferral tamara	6.75 ± 0.24	1.94 ± 0.17	3.5 ± 0.19	4.16 ± 0.18
Feteasca alba	5.23 ± 0.24	1.43 ± 0.13	2.7 ± 0.2	3.48 ± 0.19
Gaïdouria	5.67 ± 0.36	1.64 ± 0.19	2.99 ± 0.24	3.81 ± 0.2
Grenache	5.29 ± 0.27	1.47 ± 0.1	2.83 ± 0.15	3.37 ± 0.21
Hunisa	8.28 ± 0.35	2.28 ± 0.19	4.43 ± 0.25	4.95 ± 0.26
Pehlivan kara = Papigi kara	6.61 ± 0.36	1.91 ± 0.22	3.21 ± 0.31	3.68 ± 0.19
Kravi tzitzi	7.02 ± 0.32	1.92 ± 0.23	3.5 ± 0.21	3.94 ± 0.17
Local black	5.52 ± 0.36	1.46 ± 0.22	3.31 ± 0.28	3.81 ± 0.2
Mavrud	6.86 ± 0.27	2.33 ± 0.18	3.93 ± 0.2	4.29 ± 0.19
Merlot	6.07 ± 0.33	1.51 ± 0.16	3.01 ± 0.22	3.85 ± 0.25
Meslier Saint-François	5.6 ± 0.63	1.54 ± 0.25	3.09 ± 0.42	3.3 ± 0.29
Mourvèdre	6.21 ± 0.42	1.52 ± 0.17	3.09 ± 0.24	3.73 ± 0.29
Muscat à petits grains noirs	7.26 ± 0.26	2.24 ± 0.17	4.14 ± 0.25	4.14 ± 0.23
Muscat à petits grains roses	5.31 ± 0.29	1.37 ± 0.2	3 ± 0.26	3.13 ± 0.19
Pembe Gemre	6.94 ± 0.35	2.11 ± 0.24	3.92 ± 0.3	3.76 ± 0.16
Pinot noir	6.37 ± 0.33	1.73 ± 0.21	3.47 ± 0.19	3.9 ± 0.28
Roussanne	6.52 ± 0.26	1.43 ± 0.17	3.33 ± 0.26	4.15 ± 0.23
Sauvignon	6.51 ± 0.32	1.91 ± 0.18	3.49 ± 0.24	3.69 ± 0.22
Sliva	6.91 ± 0.43	1.9 ± 0.25	3.63 ± 0.29	3.98 ± 0.21
Syrah	5.42 ± 0.37	1.66 ± 0.2	3.16 ± 0.29	3.22 ± 0.19
Tachtas	5.98 ± 0.24	1.64 ± 0.15	2.99 ± 0.21	3.79 ± 0.21
Vermentino	6.52 ± 0.39	1.98 ± 0.22	4.16 ± 0.3	3.59 ± 0.15
Wild individuals				
La Calmette (Fr)	5.43 ± 0.29	0.97 ± 0.18	2.69 ± 0.24	3.7 ± 0.24
La Calmette 10 (Fr)	5.07 ± 0.36	1.23 ± 0.21	2.78 ± 0.25	3.34 ± 0.24
Camp Saure 11 (Fr)	5.3 ± 0.18	1.07 ± 0.14	2.51 ± 0.14	3.37 ± 0.17
Chalabre 4 (Fr)	4.91 ± 0.23	0.95 ± 0.11	2.32 ± 0.15	3.62 ± 0.2
Col de la Babourade 7 (Fr)	5.13 ± 0.38	1.02 ± 0.19	2.52 ± 0.21	3.29 ± 0.29
L'Escale 13 (Fr)	5.62 ± 0.37	1.13 ± 0.18	2.88 ± 0.23	3.6 ± 0.18
L'Escale 14B (Fr)	4.82 ± 0.33	0.81 ± 0.12	2.22 ± 0.17	3.31 ± 0.16
L'Escale 16 (Fr)	5.34 ± 0.3	1.19 ± 0.14	2.73 ± 0.2	3.61 ± 0.25
L'Escale 17 (Fr)	4.91 ± 0.27	1.01 ± 0.16	2.36 ± 0.18	3.58 ± 0.2
L'Escale 18 (Fr)	5.16 ± 0.47	0.71 ± 0.16	2.31 ± 0.22	3.94 ± 0.39
L'Escale 20 (Fr)	5.17 ± 0.3	0.91 ± 0.14	2.44 ± 0.18	3.47 ± 0.19
Pic Saint-Loup H (Fr)	5.19 ± 0.4	0.79 ± 0.15	2.27 ± 0.21	3.77 ± 0.29
Rivel 1 (Fr)	5.92 ± 0.6	1.01 ± 0.3	2.79 ± 0.32	4.08 ± 0.3

Table 3.1 Accessions used in this study. Dimensions are reported with mean±sd and given in mm.

Fig. 3.1 Localisation of the investigated sites.

Grapevine Biological Resources Center; https://www6.montpellier.inra.fr/vassal); it consists of varieties from seven countries from continental Europe and the Near East, where viticulture has a long history. Wild individuals were sampled *in natura* from seven populations in France. Our reference modern dataset thus gathered 1410 pips.

Archaeological material comes from three sites, as summarized in Table 3.2: Dikili Tash in the region of Macedonia, northern Greece (Late Neolithic, 4500-4000 BC) and two sites in the Peloponnese, southern Greece, P.O.T.A. Romanou (Early Bronze Age, ca 2700-2200 BC) and Tsoungiza (Late Middle Bronze Age, ca 1700-1620 BC) (Fig. 3.1). All these sites have yielded large concentrations of carbonised grape pips. All grape pips analysed consist of subsamples of at least 100 pips from larger assemblages, in order to first test the morphometric methods. Grape pips from P.O.T.A. Romanou have already been studied using geometric morphometrics (Valamoti et al 2020, Pagnoux et al 2021) and those from Tsoungiza have been studied (Allen and Forste 2020) using the metrical indices from Stummer (1911) and Mangafa and Kotsakis (1996).

All pips, modern and archaeological, were photographed in dorsal and lateral views using a stereomicroscope coupled with a digital camera. On each pip, four length measurements were manually recorded using ImageJ (http://imagej.nih.gov/ij): total length (L), length of

Table 3.2 Archaeological samples used in this study.

Site	Region	Chronology	Number of samples	Number of pips	Reference
Dikili Tash	Macedonia	Late Neolithic	4	200	Pagnoux et al 2021; Valamoti unpublished
Romanou	Peloponnese	Early Bronze Age	2	210	Valamoti et al 2020; Pagnoux et al 2021
Tsoungiza	Peloponnese	Late Middle Bronze Age	1	100	Allen and Forste 2020

the stalk (LS), position of the chalaza (PCH) and maximum breadth (B). Nomenclature followed and measurements replicated the methods of Mangafa and Kotsakis (1996). To focus on relative changes, log-shape ratios (lsr) were calculated as follows:

We also derived the synthetic index proposed by

$$lsr_{\{L,LS,PCH,B\}} = log \frac{\{L, LS, PCH, B\}}{\sqrt[4]{L * LS * PCH * B}}$$

Stummer (1911), and the four proposed by Mangafa and Kostsakis (1996) (hereafter cited as $MK_{1,2,3}$ and $_4$) as follows: Here, we calculated two new indices, lsr and lsr_trad,

$$Stummer = \frac{B}{L}$$

$$MK_1 = -0.3801 - \frac{30.2 * LS}{L} + 0.4564 * PCH - 1.386 * L + \frac{2.88 * PCH}{L} + 9.4239 * LS$$

$$MK_2 = 0.2951 - \frac{12.64 * PCH}{L} - 1.6416 * L + 4.5131 * PCH + \frac{9.63 * LS}{L}$$

$$MK_3 = -7.491 + 1.7715 * PCH + \frac{0.49 * PCH}{L} + \frac{9.56 * LS}{L}$$

$$MK_4 = 0.7509 - 1.5748 * L + 5.297 * PCH - \frac{14.47 * PCH}{L}$$

using linear discriminant analyses (further abbreviated LDA, Fisher 1936), based on natural measurements and log-shape ratios, respectively. Looking for such first-order linear combination has the merits of simplicity (only measurements and not ratios/products are used) and consistency (each measurement is used once and weighted by its own coefficient).

Traditional morphometrics were compared to geometric morphometrics analysis as the current gold standard for wild/domesticated identification. We used outline coordinates (x; y) extracted from the images, centered, scaled using the centroid size, aligned and normalized for the position of their first points. For each view, elliptical Fourier transforms were used to convert the contour geometry into "Fourier coefficients" (Bonhomme et al 2014). The number of harmonics retained assembled 95% of the total harmonic power (5 for both views). With four coefficients per harmonic, 40 Fourier coefficients were used as quantitative variables describing the shape (which is the form minus the size) for all subsequent analyses.

For all the LDAs, a permutational approach allowed us both to address the imbalance between wild and domesticated sample sizes in our dataset (Evin et al

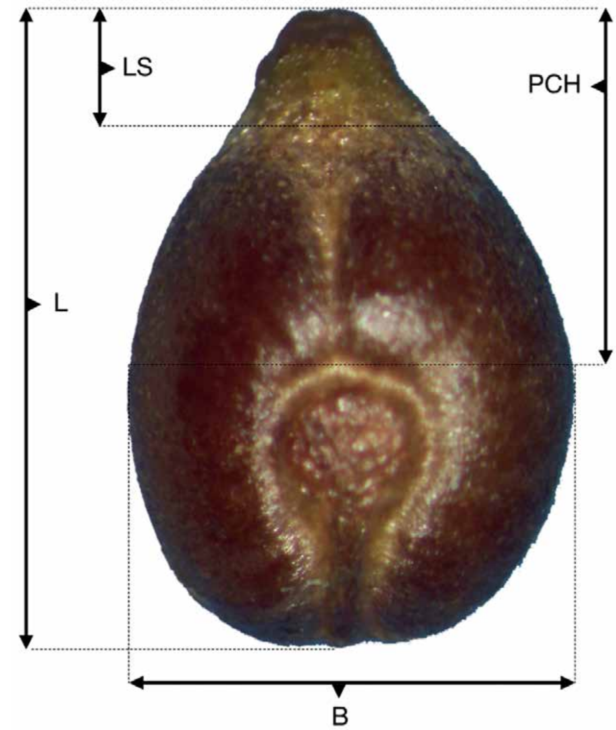

Fig. 3.2 Dorsal view of a grapevine pip, here from the *Vitis vinifera* subsp. *sylvestris* (wild) individual "Pic Saint-Loup 13", with indications of morphometric measurements: L (total length), LS (length of the stalk), PCH (position of the chalaza), B (pip breadth).

2013; Bonhomme et al 2020b), and to increase sampling robustness. We sampled, 10^3 times, 390 pips in each class (the smallest sample size between wild and domesticated classes). Fig. 3.3 presents the density distributions for both natural measurements, log-shape ratios, and all the indices derived from them, for wild and domesticated accessions.

We then benchmarked the performance at distinguishing modern wild and domesticated pip forms based on these seven indices (*Stummer*, MK_1, MK_2, MK_3, MK_4, *trad* and *lsr_trad*) and on shape descriptors (*EFT*) using "leave-one-out" cross-validation. Accuracies (the proportion of correctly classified pips) were reported both globally and by class (Fig. 3.4). A good model should both maximize global accuracy and minimize (absolute) difference accuracies between classes, i.e. not over/underestimate a certain class (wild or domesticated).

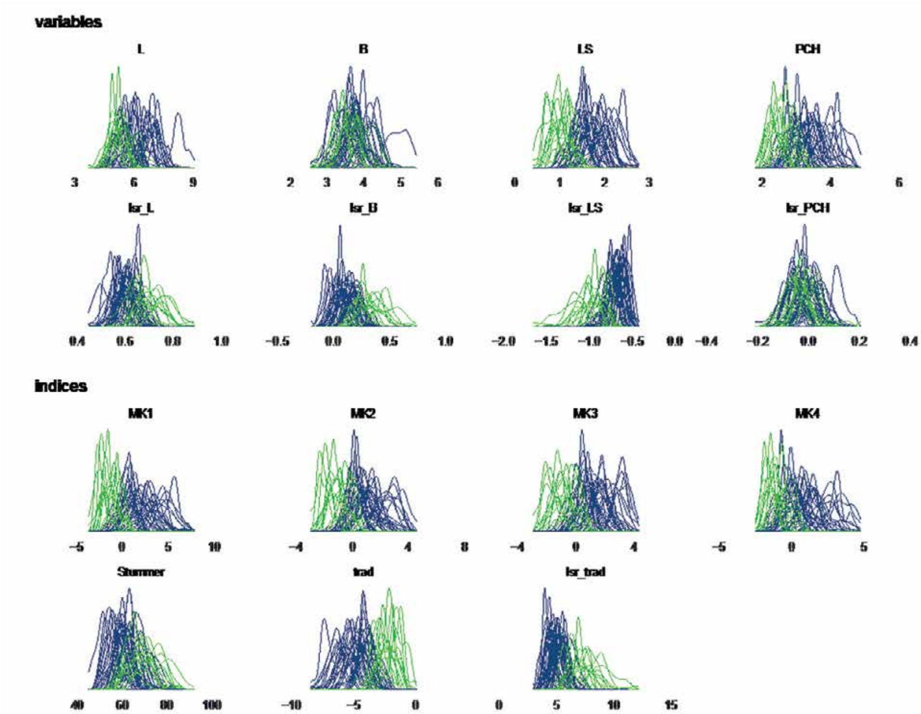

Fig. 3.3 Distributions of the length measurements and their corresponding log-shape ratios (variable panel), and of the former synthetic indices and those introduced here (indices panel). Mean density distribution (thick trait and filled are) are displayed for wild (green) and domesticated (blue) classes. Invidual accessions are also represented with thin coloured traits.

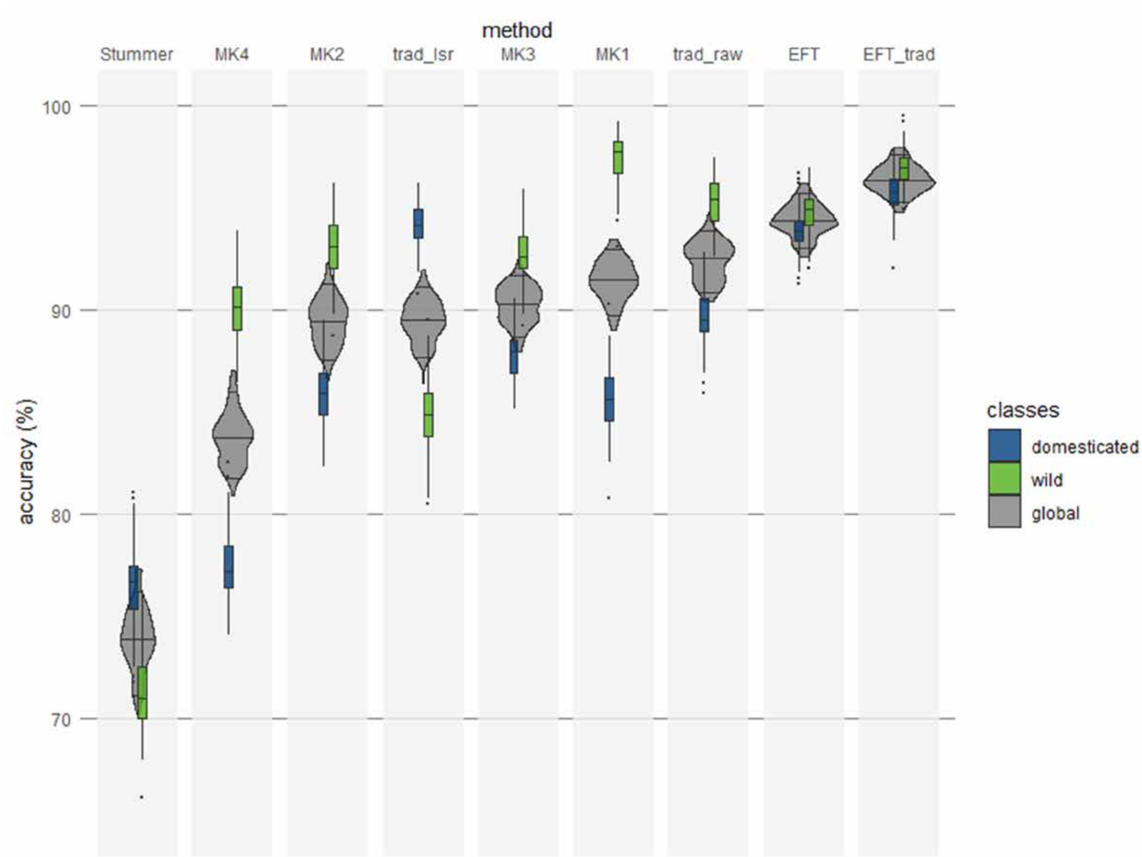

Fig. 3.4 Benchmarking identification performances for the seven indices for the reference collection. Violin distributions indicate global accuracies; boxplot classes accuracies. Distributions were obtained from 1000 permutations of balanced dataset (N=420).

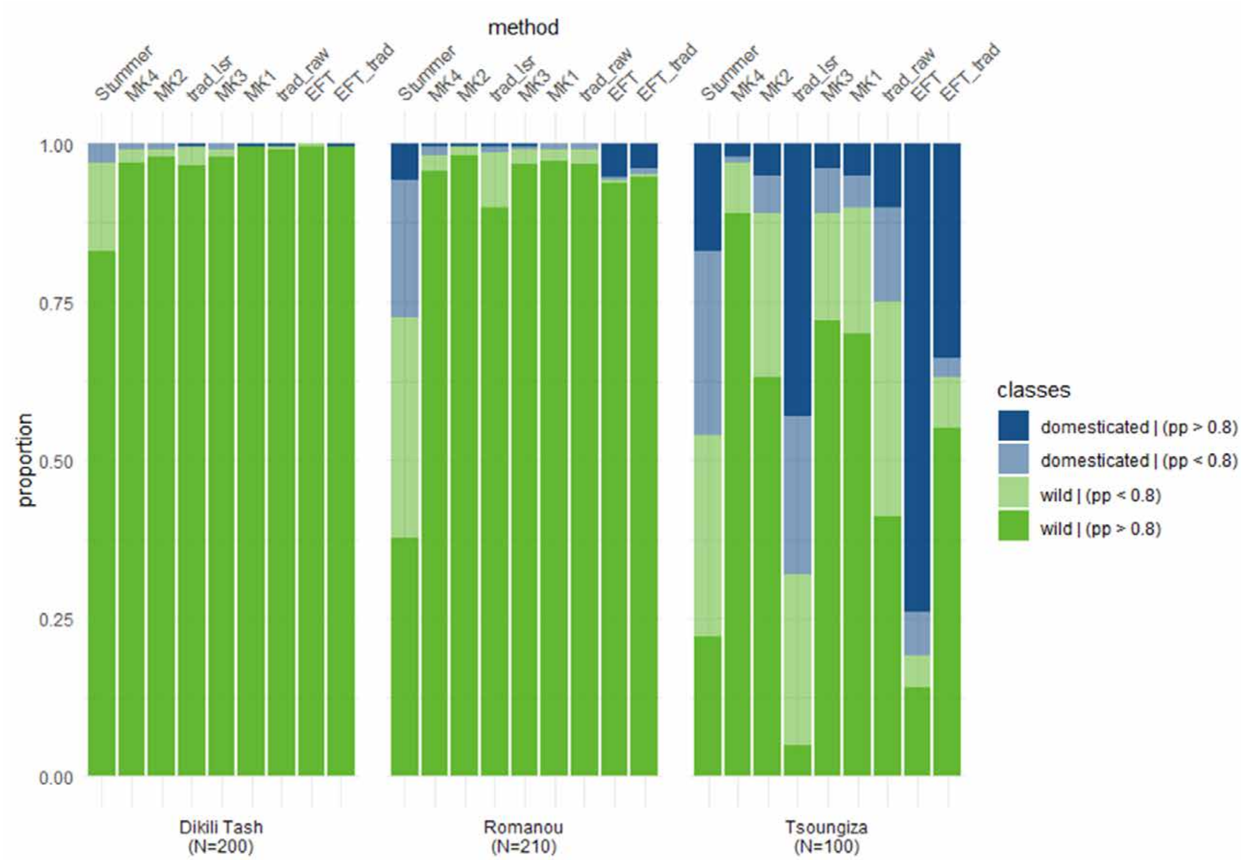

Fig. 3.5 Archaeological inference. Proportion of wild and domesticated grapevine are displayed for each site (panels) and each index (columns). Assignations are based on majority rule over 1000 permutations. Transparent areas indicate pips for which posterior probabilities were, on average, below 0.8.

Finally, the (10^3 permutations × 8 methods) LDAs obtained on the modern material were used to infer the domestication status (wild/domesticated) of the archaeological materials. For each of the eight methods, each pip was classified 10^3 times as either wild or domesticated: we used a majority rule for the definitive assignation and also calculated the average posterior probability associated with these winning assignations. Eventual ties (exactly 500 votes for “wild” and for “domesticated”) were resolved using the highest mean posterior probability. For each site, we calculated the proportion of pips assigned to the domesticated/wild type according to each model, and distinguished those with an average posterior probability > 0.8 (Fig. 3.5).

3.3 Results

The four measurements on the 1410 pips allowed us to assess the resulting distributions to identify wild and domesticated grapevines (Fig. 3.3). The density distribution for LS, the “beak length” was the single measurement that shows the best differentiation between wild and domesticated grapevine, on average, but also at the accession scale. By contrast, B (the breadth of the pip) is the worst descriptor in these respects. Log-shape ratios seems to improve differentiation (e.g. lsrB compared to B) compared to single measurements, except for lsrPCH that shows an increase in distribution overlapping, compared to PCH.

We benchmarked the performances of the five synthetic indices already published, those of the two indices we calculated from our measurements (trad and lsr_trad) and of outline analysis (EFT – Fig. 3.4). First, the results confirm that the best discrimination between pips of wild and domesticated grapevines is obtained using geometric morphometrics. EFT gives the best global accuracy (94.4%) and the minimal difference between performances for wild and domesticated grape pips. One can see that results obtained from traditional measurements, although inferior, are very good; trad provide correct identification for 92.4% of the pips, on average. Moreover, the formulas from Mangafa and Kostakis also give good results, especially MK1 and MK3 which allow the correct identification of respectively more than 91.4% and 90.2% of the pips. The trad index outperforms the MK1 index only by 1.9%. The worst discrimination accuracy was obtained with the Stummer index (73.9%). MK4 was quite better (83.7%) but less accurate than the three other indices proposed by Mangafa and Kotsakis and the lsr_trad index.

The absolute difference between class accuracies (i.e. the difference between correct identification of the wild and domesticated compartments) is clearly higher for all the indices based on traditional measurements than for EFT. Most of the methods (MK formulas and trad) allow the discrimination of wild grape pips with a greater accuracy than the domesticated ones. This means that, when these methods are applied to archaeological pips, the relative proportion of wild grapevine to domesticated will likely be overestimated. In contrast, the Stummer and lsr_trad indices identify with greater class accuracy the pips from domesticated grapevines and are therefore expected to overestimate the proportion of domesticated grapevine in archaeological assemblages. Because these last two methods (Stummer and lsr_trad) use ratios and logged measurements for lsr_trad rather than natural measurements, they put less emphasis on pip size. This difference may reduce confusion about the identification of smaller domesticated seeds, which overlap in size with wild seeds.

Once the differences in the performance of the various methods on fresh material have been established, it is also necessary to consider possible interactions with the deformations induced by the carbonisation of the archaeological material. Various experimental studies have indeed shown that carbonisation leads to a reduction in the size and certain deformations in the shape of the seeds (Smith and Jones 1990; Mangafa and Kotsakis 1996; Ucchesu et al 2016; Bouby et al 2018). Generally, the domesticated seeds take on a more roundish appearance more characteristic of the wild grapevine. It should be stressed, however, that the long beak, which is very characteristic of the domestic vine, is weakly affected by these deformations. The consequence is that experimentally charred wild and domesticated *Vitis* seeds can still be reliably discriminated using both lsr_trad and EFT methods (Bouby et al 2018). However, the performance of other methods will necessarily be more affected by charring, those that take into account size, which is strongly modified by charring, and those that do not take into account beak size or shape.

If we now consider the archaeological material, in Dikili Tash, the earliest site (Late Neolithic), 0 to 1% of pips were classified as of the domesticated form with a posterior probability > 0.8, irrespective of the method applied. The same results were observed for Romanou (Early Bronze), setting aside the results obtained with the Stummer index, which classifies 30% of the assemblage as domesticated. The first solid evidence of domesticated forms appears in the Tsoungiza assemblage (Late Middle Bronze / Early Mycenaean) where more than 75% of the pips are identified as domesticated using EFT. The trad index, the best performing index on modern material, only reports 25% of pips of the domesticated form, including 11% with a posterior probability > 0.8. Both the Stummer and the lsr_trad indices report a majority of pips of the domesticated form.

Among all the indices based on length measurements lsr_trad is the one giving the best results on modern domesticated pips. Considering the changes in size and shape caused by carbonization it is likely that this index performs, comparatively, even better on charred pips, being less affected by size changes.

3.4 Discussion

3.4.1 Assessing the performances of traditional morphometrics on modern reference material

The modern reference material used in our study has proven crucial towards choosing a method that reliably allows the distinction between wild and domesticated grapevine. Testing measurements, indices, formulas or any method first on modern material is crucial to evaluate the accuracy and the suitability of the chosen descriptors. Recent works confirm that a wide reference collection allows to build more robust models, based on more representative modern groups (wild and domesticated compartments), and therefore to identify archaeological material with higher confidence (Terral et al 2010; Bouby et al 2013, 2021; Pagnoux et al 2015; Bonhomme et al 2020b). Here we have used an extended modern collection, which is used to systematically compare the performances of various methods based on traditional morphometric descriptors (Stummer index, MK1, MK2, MK3, MK4, trad and lsr_trad) to outline analysis (EFT).

The first point to be made is that traditional measurements of grape pips allow a distinction between wild and domesticated grapevines with a high accuracy, except for the Stummer index, which allows the correct identification of a smaller proportion of modern pips. The limited distinctive potential of the Stummer index lies in the fact that it considers only two descriptors of the grape pip, the distances B and L. The index of these measurements does not take into account a main distinctive feature, that of the length of the stalk, and thus insufficiently reflects the pips morphological characteristics between the two subspecies of grape, wild and domesticated.

As a matter of fact, to distinguish between the two subspecies, the length of the stalk is of key importance. This descriptor has long been considered as a characteristic of the domesticated grapevine (Levadoux 1956). Previous studies aiming to identify wild and domesticated grapevine among archaeological grape pips have revealed the value of this measurement (Smith and Jones 1990; Mangafa and Kotsakis 1996; Bouby et al 2013). Additionally, a more recent experimental approach of the effect of charring on the identification of grape pips also demonstrated the robustness of the length of the stalk in distinguishing wild/domesticated grape even after charring (Bouby et al 2018). The stalk dimension is also a reliable criterion as regards its independence related to the number of pips per berry: it is not affected by the number of pips per berry compared to other size and shape characters (Bonhomme et al 2020a). Along with the length of the stalk, the length of the pip and the position of the chalaza appear to be relevant to the distinction between wild and domesticated pips, even when carbonized (Mangafa and Kotsakis 1996). Our study confirms that by contrast, the breadth of the pip is the less powerful descriptor to distinguish between wild and domesticated grapevine (Mangafa and Kotsakis 1996; Bonhomme et al 2020a).

However, the use of shape-based rather than size-based criteria allow an even better identification of domestication status, because shape is less affected by environmental parameters than size. Shape is also less affected by carbonization. For all these reasons, already underlined by previous studies (Mangafa and Kotsakis 1996; Bouby et al 2018), the use of criteria based on shape allow a better identification of grape pips and especially of carbonized pips. Geometric morphometrics give the best results, but formulas MK1 and MK3, based on composite indices and not only on size parameters, give good classification rates, superior to 90%. In their paper, Mangafa and Kotsakis recommend the use of MK2 and MK3, as more adapted to the analysis of carbonized material because they use fewer simple size variables than ratio variables (Mangafa and Kotsakis 1996). Our benchmark confirms that MK3 allows a better identification of domesticated grape pips compared to the other formulas: this formula may therefore be considered as a very good method to identify archaeological grape pips. On the basis of our results, MK2 is less powerful to distinguish between wild and domesticated, but more efficient than MK4.

Log-shape ratios allow a good distinction between wild and domesticated grapevine when applied to charred remains, as it has already be demonstrated (Bouby et al 2013; Bouby et al 2018). EFT offer even more accurate criteria but data acquisition is less straightforward.

3.4.2 Selecting the appropriate method for exploring charred archaeological pips

In light of our results, different histories of grapevine domestication could be written by picking one method rather than another. The use of the Stummer index, whose performance is limited on modern material as we have shown, may have dated the identification of the first domesticated grapevines in Greece and elsewhere to an earlier period. Indeed, this method is as powerful as the other ones in identifying "typical" wild type, but less powerful when dealing with "less typical" shapes, as shown by our results on the archaeological material. In this study, up to 25% of the sample from Early Bronze Age P.O.T.A. Romanou can be classified as domesticated using the Stummer index, while the other methods classify less than 10% as domesticated. Previous studies based on the Stummer index support the interpretation that the first domesticated morphotypes occurred as early as the Late Neolithic at Dimitra (Renfrew, JM 1997) and Sitagroi (Renfrew, JM 2003) in Macedonia, while the grape pips from Dikili Tash are considered as wild or "intermediate" (Logothetis 1970). Our results suggest that these conclusions should be considerably tempered.

Conversely, while the Stummer index overestimates the presence of domesticated forms, the MK formulas overestimate the presence of the wild grapevine. In our study, more or less 10% of the archaeological pips dated to the Late Middle Bronze Age (Tsoungiza, Peloponnese) are classified as domesticated using any of the four formulas or direct traditional measurements, while this rate is close to 75% using geometric morphometrics and log-shape ratios. Therefore, the use of MK formulas could have led to underestimate the presence of domesticated grapevine in Greece during the Bronze Age, as shown by a recent research based on geometric morphometrics (Pagnoux et al 2021).

Two sources of bias are combined when applying models trained on modern material to archaeological material. First, a purely statistical by-product arises from contrasted class accuracies: here the probability of being classified as "wild" is overestimated. Since it is obtained on modern material, this bias is likely carried, but also overwhelmed by an opposite effect, when inferring domestication status on archaeological material. As a matter of fact, when charred, pips tend to become rounder, which is not a statistical but a taphonomic effect which is expected to unduly classify as wild, "true" domesticated pips.

As mentioned above, charring has a strong impact on seed size and also affects seed shape, leaving the beak relatively unaffected. Charring therefore has a variable impact on the performance of the methods aiming to discriminate wild/domesticated grape pips, depending on whether they take into account the size of the seeds and the shape of the stalk. As a result, the EFT and lsr_trad methods are relatively unaffected by charring, because they do not use size while they take into account the stalk. The methods MK1, MK2, MK3, MK4 and trad will necessarily be more affected by charring, because they directly rely on distance measurements that express size. The performance of the Stummer index will be even more impacted as it does not directly take into account the size and shape of the beak. Further deciphering the interrelated effects of the statistical method and of the deformations due to charring will require more dedicated experimental work.

3.4.3 Archaeological application and the domestication of grapevine in Greece

In this study, all methods give the same result for the Late Neolithic Dikili Tash, and this result is consistent with previous studies on other samples from the same site, analyzed using MK formulas (Mangafa and Kotsakis 1996) or geometric morphometrics (Pagnoux et al 2021): grape pips are all morphologically wild. However, indications of grapevine cultivation during the Late Neolithic are numerous (for a review, see Pagnoux et al 2021), and the pips from Dikili Tash may represent grapevine under cultivation, wild or at an early stage of domestication, whose seeds do not bear any morphological sign of domestication (Valamoti 2015).

Describing the situation of the grapevine in Greece during the Early Bronze Age is more challenging. Few grape pips are available, contrary to the Late Neolithic finds. Grape pips from Early Bronze Age Lerna (Peloponnese) have been analyzed using the Stummer index: most of them fall into the overlapping zone, while few are considered as typical of wild grapevine and even fewer as typical of domesticated grapevine (Hopf 1962). This pattern led Hopf to suggest that grapevine is at a transitional stage at Lerna during the Early Bronze Age. However, Smith and Jones (1990) and Mangafa and Kotsakis (1996) argued that this overlapping zone corresponds not to an admixture or intermediate forms, but results from the use of inappropriate parameters.

Smith and Jones compared the results obtained by Hopf to their experimental work and suggested that these "transitional" pips could correspond to domesticated ones, since pips from cultivars experimentally charred fall into this overlapping zone of the Stummer index (Smith and Jones 1990). However, because neither we nor Smith and Jones had access to the Lerna material, it was not possible to test this hypothesis. Similarly, Early Bronze Age pips from Dikili Tash analyzed by Logothetis are not available for reanalysis. Grape pips and even more morphometric data on grape pips dated to the Early Bronze Age are hence still lacking, such that only minimal comparison material can be found. The material from P.O.T.A. Romanou, analyzed here, is therefore highly significant, as it is one of the few Early Bronze Age assemblages that can help to better understand the changes undergone by grapevine during this period. More than 90% of the pips are, on the basis of all traditional approaches, Stummer and EFT set aside, closer to the wild grapevine. However, as shown in a recent study, grape pips from Romanou are slightly different from those dated to the Neolithic: they are more elongated and/or with a longer stalk, and they tend to be less typical of the modern true wild grapevine; this change in pip shape may reflect an early stage of selective pressure towards domestication (Valamoti et al 2020). Combined to other evidence of grapevine management and intensive use since the Late Neolithic (for a recent review see Pagnoux et al 2021), the results presented here are further clues to a possible autochthonous domestication of the grapevine in Greece.

The grape pips from Tsoungiza, analysed in this study, and previously by Allen and Forste (2020) using Stummer, MK1 and MK2, provide the first morphometric results on Late Middle Bronze Age material from Peloponnese. On the basis of geometric morphometrics and log-shape ratios, they are mostly close to the domesticated grapevine. Allen and Forste (2020) reach the same conclusion, not only on the basis of morphometric results, but also due to the presence of many immature pips, that are regarded as typical of domesticated grapevine (Kroll 1999).

This result is also consistent with previous studies on Late Bronze Age sites from Central and Northern Greece (Pagnoux et al 2021) that indicate the cultivation of domesticated varieties at the time. Material from earlier periods and from other Middle and Late Bronze Age sites is nonetheless still needed to better understand the development of domesticated grapevine in Peloponnese. Indeed, wine making and wine consumption has long been thought to have started with the Mycenaean civilization (1650-1100 BC) in this region, but current archaebotanical and morphometric data seems to challenge this assumption. At Neolithic Dikili Tash, evidence of wine making has been found, consisting of grape pressings (Valamoti et al 2007, 2015) and chemical evidence in vessels (Garnier and Valamoti 2016). These elements are associated with large quantities of morphologically wild grape pips, showing that the first wine in the Aegean was probably made using wild grapevine or grapevines in an incipient form of cultivation, before the emergence of fully domesticated types; at Dikili Tash the latter seems more likely because of the large quantity of the harvest. Previous studies in the Near-East suggested that the first wine was made using grapes from wild grapevine (Miller 2008), and experimental microvinifications indeed reveal that wild grapevines are suitable to make wine (Arroyo-Garcia et al 2016), although the small size of the berries and the limited and irregular production of fruits pose challenges for wine-production (Bouby et al 2021). Evidence of wine predating the presence of the domesticated type has also been suggested in the Caucasus (Bouby et al 2021).

3.5 Conclusions

The efficiency and relevance of the methods used to distinguish wild and domesticated archaeological pips has been and still is the cause of debate, as well as the question of grapevine domestication. In this article we compare for the first time, based on a unique and diversified modern reference collection, the performance of geometric morphometrics (EFT) to traditional length measurements, and for the latter we compare the different known indices and methods mentioned in the literature. First, our results underline the necessary use of a diversified reference collection to reliably assess the different methods used for the distinction of wild vs domesticated grapevine. Then, except for the Stummer index, this study confirms the good overall performance of the methods based on length measurements compared to EFT, which, however, is still more accurate.

A good method would allow distinguishing modern wild and domesticated grapevine with a good global accuracy, would minimize differences in accuracy between wild and domesticated types and would be efficient in identifying archaeological grape pips despite the distortion induced by charring. Consequently, we show that picking one method rather than another may lead to write a different history of the grapevine domestication.

The use of wild grapevine during the Late/Final Neolithic (4500-4000 BC), perhaps at an early stage of cultivation, is confirmed by this study, as well as the use of fully domesticated type during the Late Bronze Age. The situation is still unclear concerning the Early Bronze Age (2700-2200 BC): grape pips from one site, P.O.T.A. Romanou in south Peloponnese, show a morphology close to the wild type but different from the shape of the Late Neolithic grape pips. On the basis of these results, a local domestication of the grapevine may be suggested for Greece. Notably in Late Middle Bronze Age Tzoungiza (1700-1620 BC) domesticated grapevine is clearly identified. If we take into account the temporal relationship between the P.O.T.A. Romanou and Tsoungiza archaeological assemblages, it appears that from the 3rd mill BC to the first half of the 2nd mill BC there is a considerable increase of domesticated grape pips that may reflect a regional change due to local cultivation leading to the development of morphologically domesticated pips.

Many questions remain open: from a methodological point of view, the importance of the operator in taking length measurements need to be investigated, while more archaeological material is necessary to better understand the history of grapevine domestication in the Aegean.

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Chapter 4

Land management and food resources in Bronze Age central Greece. Insights from archaeobotanical assemblages from the sites of Agia Paraskevi, Kynos and Mitrou (Phthiotida)

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Abstract

This paper integrates analyses of charred wood and non-wood plant macroremains and morphometric analysis of grape pips (*Vitis vinifera*) aiming to provide insights into the vegetation, management of woodland resources, farming activities and dietary habits at three Bronze Age sites in Phthiotida, central Greece: Platania-Agia Paraskevi, Mitrou and Kynos. The sites span the entire Bronze Age (3200-1100 BC), a period of significant transformations in the social and economic realm. The evidence is based on remains retrieved by flotation from 396 soil samples. Wood charcoal analysis demonstrates a rich diversity of plant taxa with olive and deciduous oak commonly used at all periods and sites for fuel, alongside trees of the evergreen woodlands, especially *Arbutus*, therefore indicating the management of the lowlands and the meso-Mediterranean vegetation growing on the foothills near the settlements. Finds of olive and grapevine wood suggest management of both species while morphometric analyses of grape pips point towards an increase of domesticated grape pip morphotypes during the course of the Bronze Age and therefore to a systematic cultivation of the plant. Cereal staples included barley, einkorn, emmer and *T. timopheevii* wheat with free-threshing wheat and spelt wheat being poorly represented in the investigated finds; no millet was identified in the assemblages. A wide range of pulses, found in large quantities, most likely contributed significantly to the diet of humans and/or animals: lentils, bitter vetch and Celtic bean were grown as crops but the role of grass pea and chickpea is less straightforward. Fruit trees were also harvested, while the exploitation of various environmental niches, potentially not only for cultivation (i.e. grazing, building and basketry resources, etc), is also hinted by the available wild flora remains.

Keywords: *Bronze Age central Greece, archaeobotany, morphometric analysis, woodland management*

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4.1 Introduction

Archaeobotanical research has the potential to offer precious insights about the interaction between human societies and the natural and cultural environment. Different lines of archaeobotanical research offer patches of information and when integrated, they become a powerful tool for comprehending past societies. For prehistoric Greece such an integration of archaeobotanical remains, bringing together palynological, anthracological and macroscopic plant remains (other than charcoal) are rare except for cases where specific plants are investigated such as the grapevine (e.g. Valamoti et al 2020) or the olive (Margaritis 2013; Valamoti et al 2018). One of the major axes of investigation within the ERC project PlantCult was the investigation of the long-term interaction between plants and people in prehistoric southeastern Europe. The area of Phthiotis lends itself to such an approach and we focus on the study of archaeobotanical assemblages from the three Bronze Age sites of Mitrou, Agia Paraskevi-Platania (hereafter Agia Paraskevi) and Kynos. The sites span the 3rd to 2nd mill BC that correspond to the Early, Middle and Late Bronze Age. We explore the management of natural vegetation and the cultivation of crops to fulfill the various needs of the human communities that inhabited our study region through the integration of anthracological and other macroscopic plant remains, including morphometric analysis of grape pips. This approach allows us to offer a more complete picture for the past, offering at the same time a diachronic perspective.

4.2 The natural setting

Phthiotis, our study area, is located in eastern central Greece, opposite the island of Euboea (Fig. 4.1a). The topography is highly varied. Along the north Euboean Gulf, the narrow coastal lowland fringe where the sites of Mitrou (12 m asl) and Kynos (10 m asl) are located, is succeeded by middle and high altitude (>1000 m asl) land, within a short distance from the coast. Further to the north in the broader area of the Maliakos Gulf where the coastal plain is bordered by the foothills of high mountain ranges to the north, south and west, lies the site of Agia Paraskevi (7 m asl) (Fig. 4.1 a). In this area, the Sperchios River exiting in the Maliakos Gulf has shaped the geography through depositional processes, resulting in the prolongation of the delta and the formation of a flat alluvial plain (Vouvalidis et al 2010, 65 and references therein).

The bioclimatic characteristics and the corresponding vegetation types in the study area are summarised in Fig. 4.1 b following Bohn et al (2002/2003). At present, much of the low and middle altitude areas are cultivated and therefore little remains of the natural vegetation. Thermo-Mediterranean sclerophyllous forests and xerophytic scrub characterise the narrow coastal zone along the north Euboean Gulf. Meso-Mediterranean evergreen woodlands and scrub characterise the hilly land to the west of the coastal zone as well as the northern part of the study area from the coastline of the Maliakos Gulf to the foothills of the surrounding mountains. Evergreen woodlands are succeeded in altitude by meso/supra-Mediterranean and sub-Mediterranean thermophilous oak and mixed forests. Supra-Mediterranean fir forests consisting of dominant *Abies cephalonic*a with *Pinus nigra* grow in the highest part of the mountains up to the tree line. *Platanus orientalis* alluvial forests and brackish water *Tamarix* scrub can be found in the area.

4.3 The sites

The Bronze Age on the southern and central Greek mainland (Helladic culture), is subdivided into three phases: the Early Bronze Age (EBA) or Early Helladic period (EH) (3200-2100 BC), the Middle Bronze Age (MBA) or Middle Helladic (MH) (2100-1700/1600 BC) and the Late Bronze Age (LBA) or Late Helladic (LH) (1700/1600-1100 BC). Archaeological research in the area of Phthiotis has provided evidence for long-term habitation already since the 4th mill BC testified by Final Neolithic finds in surface surveys and excavations, including the three sites that are presented in this study. The shift of habitation to central eastern mainland Greece during the 3rd mill BC, is documented in the flourishing of Early Bronze Age settlements (cf. Rutter 2001 and for the area under study, i.e. Phthiotida, see also Zahou 2009, 2019) of which Mitrou is a good example (Kramer-Hajos and O'Neill 2008; Van de Moortel and Zahou 2012; Van de Moortel et al 2018).

The sites of Mitrou and Kynos (Fig. 4.1), are located on the coastline of the North Euboean Gulf. The southernmost site, Mitrou, is a small tidal islet (3.6 ha) in the Bay of Atalante and the ancient settlement covers its entire surface (Van de Moortel and Zahou 2012, 1131, fig. 2; Karkanas and Van de Moortel 2014, 199, fig. 1). The islet is flat, rising gently to the north to about 12m asl. At low tide it is connected to the mainland and at high tide it is located only a hundred meters from the mainland coast. During the Bronze Age the site probably was part of the mainland, but still located close to the sea (Karkanas and Van de Moortel 2014, 199). Systematic excavations by the Mitrou Archaeological Project (2004-2008), revealed stratified sequences with more than 40 occupational phases with indoor floors and exterior surfaces, showing that the site was occupied without interruption from the Early Helladic IIB into the Late Protogeometric phase (ca 2400-900 BC) (Van de Moortel and Zahou 2012, 1132-1138; Karkanas and Van de Moortel 2014, 202). Abundant plant remains were recovered from fire destruction layers, pits, hearths, surfaces, floor deposits and fills from both internal and external spaces (Karathanou and Valamoti 2013; Karathanou 2019).

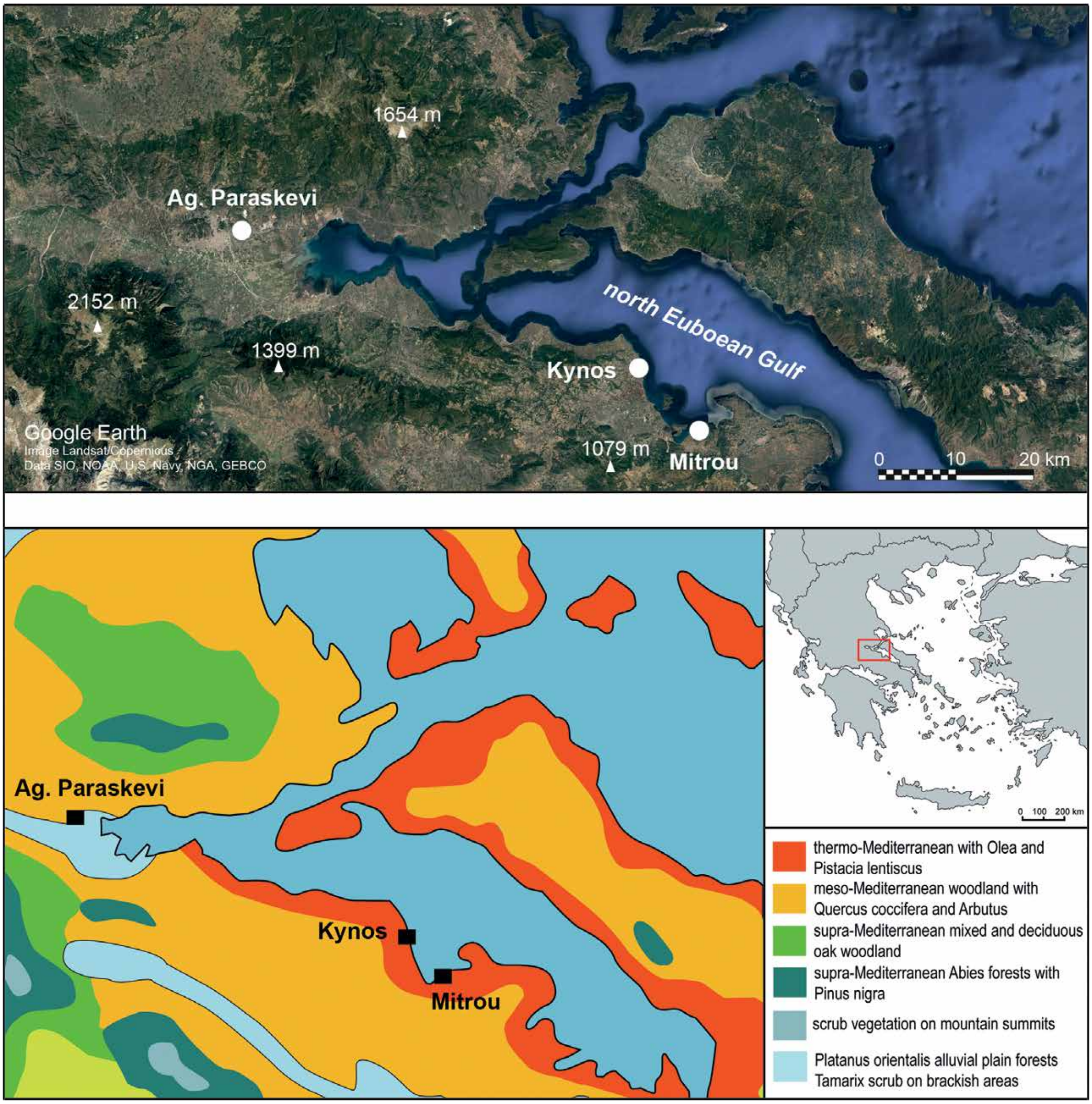

Fig. 4.1 a The location of the studied sites (Map data: Google, Image Data SIO, NOAA, U.S. Navy, NGA, GEBCO); b Bioclimatic zones and related vegetation types in the study area (after Bohn et al 2002/2003).

The site of Kynos is located on a coastal low mound northeast of the modern village Livanates overlooking the north Euboean Gulf (Fig. 4.1). The mound was formed by the debris of successive occupations starting in the Final Neolithic (4300-3200 BC) and lasting to the Early Byzantine period (5th-6th c AD). The material discussed here derives from successive architectural phases of the later part of the Late Bronze Age, mostly the Late Helladic IIIC. The structures were built with mudbrick walls on stone foundations. According to their size and contents, the latter attesting to food preparation, storage and craft production (e.g. textiles, pottery), they were domestic units (Dakoronia 2010; Kounouklas 2011, 2015). Successive phases are distinguished by burnt destruction events which also provided excellent preservation of macrobotanical remains. Several crops were found stored in vessels and facilities (e.g. *pithoi* and clay bins) preserved *in situ*, and abundant plant remains from daily activities (crop processing, fuel spending, discarding) were recovered from the destruction layers on the floors and the rebuilding fills above them (Karathanou and Valamoti 2013; Karathanou 2019; Kounouklas et al 2021).

The northernmost site of Agia Paraskevi (Fig. 4.1) is a low mound (7 m asl) overlooking the Sperchios River basin and the Maliakos Gulf (Papakonstantinou et al 2015). Multidisciplinary research coupled with ^{14}C dating indicate that the area, which today is located 5.5 km from the present coastline, shifted from a marine palaeoenvironment (ca 5500 BC), to a coastal – lagoonal one (ca 3500 BC) and finally to a freshwater marshy environment (ca 2500 BC) (Vouvalidis et al 2010). Habitation at the site dates from the Late Neolithic to the Late Bronze Age and Historical times. Excavations at the center of the mound have revealed the architectural remains of a settlement of the Middle Helladic II period. Stone foundations of five apsidal buildings and parts of two more, some simultaneously used and others successively, were uncovered on either side of a street running along the N-S axis of the settlement and further separated by smaller streets/alleys. These domestic units usually comprised more than one parts/rooms and few reconstruction phases each, in cases distinguished by fire destruction debris. Pottery of a wide variety, abundant small finds and bioarchaeological materials including charred plant remains were contained in the deposits excavated both within the buildings and in the open spaces (Gkotsinas et al 2014; Papakonstantinou et al 2015; Papakonstantinou and Krapf 2020).

4.4 Materials and methods

A total of 396 sediment samples were collected from the three sites corresponding to 9506 litres of soil (Table 4.1). Though all prehistoric periods from the Early Bronze Age onwards are represented, most samples are dated to the Middle Bronze Age, followed by those of the Late Bronze Age. Sampling was systematic at Mitrou resulting in the representation of all excavated contexts. Systematic sampling was also applied during the first two excavation seasons at Agia Paraskevi, followed by sampling on a judgement basis in the following years. At Kynos, samples from the first campaign in the `80-90s were also collected in a less systematic way. Nevertheless, all undisturbed units were sampled systematically during the latest salvage excavation of an extensive clay construction that sealed the fire destruction layer of one of the settlement buildings at the site (Kounouklas et al 2021). Despite the discrepancy of sampling intensity among the three sites and in some cases within the same site, a wide variety of contexts are represented in the datasets: fills in open spaces and between floors, indoor destruction layers usually on top of floors, as well as more confined/specific features like vessels, bins, hearths, ovens, clay structures, pits, burials, etc.

Samples were processed by flotation, using a variant of the Ankara machine (French 1971) and by the wash-over

Cultural Period	Site	No of samples	Total volume (l)
EBA	Mitrou	18	468
EBA/MBA	Mitrou	5	88
MBA	Mitrou	48	3186
	Agia Paraskevi	149	1052
LBA	Mitrou	90	4041
	Kynos	72	285
LBA/Early Protogeometric	Mitrou	14	386
TOTAL		396	9506

Table 4.1 Number of soil samples and total volume processed per period at each site.

method in the case of the Kynos samples from the first campaign (Kenward et al 1980) due to their small volume. In all cases, the smallest mesh size used for the retrieval of floating material was 300 μm, while heavy residues were retained by a 1 mm plastic mesh.

4.4.1 Wood charcoal analysis

The study is based on the analysis of 202 flotation samples (3685 wood charcoal specimens in total) from the three Bronze Age settlements (Table 4.2). The material originates from fills and exterior areas, from burnt destruction layers in indoor contexts and from thermal structures. The provenance of the samples is shown in detail in Table 4.2. Wood charcoal macro-remains larger than 3 mm were examined for botanical identification at the ERC PlantCult project laboratory facilities (CIRI), with a Leica DM 2700M dark/bright field microscope with 50-500× magnification, and with the aid of the wood anatomy atlas of Schweingruber (1990) and the reference collection of the Departmental laboratory (LIRA). The analysis, presentation and interpretation of the wood charcoal macro-remains follow the main prerequisites of wood charcoal analysis (Chabal 1997; Asouti and Austin 2005; Kabukcu and Chabal 2021). The presence and ubiquity of the woody taxa in fills and burnt destruction layers is presented aiming to assess general aspects of access to and management of woody resources in different sites and periods. The qualitative and quantitative study of firewood remains from thermal structures that reflect short-term fuel uses is presented in a separate section. Quantification of the remains in long-term accumulation fills and dumping areas is based on fragment counts per taxon and the presentation of the data aims to tackle issues of firewood procurement strategies and woodland management diachronically. For the ease of discussing the taxonomically rich record, the woody taxa identified have been grouped in vegetation types according to their present-day distribution in bioclimatic zones (see Fig. 4.1). These are: a. Sclerophyllous Mediterranean woodland, b.

Cultural Period	EBA	EBA/MBA	MBA	LBA	MBA	LBA
Site		Mitrou			Agia Paraskevi	Kynos
Sample	no	no	no	no	no	no
fills	11		13	2	37	13
floors and burnt layers	7	5	8	12	62	25
thermal structures	2		4			1
Total no specimens analysed	990	221	1099	98	672	605

Table 4.2 The samples included in the wood-charcoal study and their provenance.

Deciduous Mediterranean woodland, c. Open woodland and scrub, d. Mediterranean mountain coniferous forests and e. Alluvial/riverine/brackish habitats. However, mixed formations at the interface of bioclimatic zones, growing under microclimatic conditions and influenced by human activity, should be considered as more realistic, especially in the areas close to the settlements.

4.4.2 Plant macro-remains other than wood

The results presented here rely on (a) 35 fully studied samples (Table 4.3), and, (b) 132 preliminarily studied samples (Table 4.4). As shown in Table 4.3, all fully studied samples come from the two Late Bronze Age sites, Mitrou and Kynos (first campaign of excavations). The 35 fully studied samples (Table 4.3) resulted from an initial number of 50 samples (33 from Mitrou and 17 from Kynos), some of which were amalgamated for the purposes of the analysis as they were from the same context and had almost the same archaeobotanical composition. The earlier periods are represented by a coarser-grained level of analysis and are only considered here in a qualitative way. The coarse level of analysis of the earlier samples involved (a) scanning of 66 samples and (b) sorting of 66 samples (Table 4.4); this procedure enabled the recording of species visible and an approximate estimation of the quantity in which the various species/genera were present in each sample. Scanning, as well as the sorting and identification that were applied to certain samples only, were performed with the aid of a stereomicroscope (X8-X40) with the contents of the coarse flot (>1mm) of each sample quickly being observed with the aid of a paint-brush; for the fine flots (1mm-300mμ) only a smaller fraction of the sample was observed (cf. Valamoti 2004, 26). Scanning, sorting and identification were performed at the LIRA (AUTH) and the Ephoreia of Evritania and Phthiotida facilities. Identifications were aided by the LIRA modern seed reference collection and various seed atlases. Taxa nomenclature presented in the tables follows that of *Flora Europaea* (Tutin et al 1964-1993). Quantification was based on the selection of a specific part of the grain, chaff, seed or fruit only in order to avoid over-representation of an item broken into several pieces (see for example Valamoti 2004, 37). Ecological information for wild taxa were sought both in Greek sources (Gennadios 1914; Huxley and Taylor 1984;

Cultural Period	Site	No of fully studied samples (amalgamated)
LBA	Mitrou	21
	Kynos (first campaign samples)	14
Total		35

Table 4.3 Number of non-wood samples fully studied per cultural period and site.

Cultural Period	Site	No of scanned samples	No of sorted samples
EBA	Mitrou	18	
MBA	Mitrou	48	
	Agia Paraskevi		40
LBA	Kynos (recent campaign samples)		26
Total		66	66

Table 4.4 Number of non-wood samples preliminarily studied (scanned and sorted) per cultural period and site.

Kavvadas 1954-1964; Eleftherochorinos and Giannopolitis 2009; Papiomitoglou 2006) and sources including Greece within their study area (Tutin et al 1964-1980; Polunin 1969; Blamey and Grey-Wilson 2004).

4.4.3 Morphometric analysis

Morphometric analysis was performed on whole carbonized grape pips from the Middle Bronze Age settlement of Agia Paraskevi and Late Bronze Age Mitrou to explore past intra-specific diversity. This material has been fully published elsewhere (Pagnoux et al 2021) and is here presented in a summarised way. Samples of at least ten whole pips have been chosen and studied from the two sites in order to increase the reliability of the analyses with a total of 77 grape pips from Agia Paraskevi (Middle Bronze Age) and 89 from Mitrou (Late Bronze Age) represented in the analysis. The shapes of the seeds were described using outline analysis based on the Elliptic Fourier Transform technique (EFT), as developed and improved by previous studies (Terral et al 2010; Pagnoux et al 2015; for a complete description of the method, see Pagnoux et al 2021). The archaeological grape pips have been compared to a reference collection of modern grape

Cultural Period	EBA				MBA								LBA						
Site	Mitrou				Mitrou				Agia Paraskevi				Mitrou			Kynos			
Provenance	fills		destruction		fills		destruction		fills		destruction		fills	destruction		fills		destruction	
No samples studied	11		13		13		8		37		62		2	12		13		25	
Taxa	no	%	no	%	no	%	no	%	no	%	no	%	no	no	%	no	%	no	%
Evergreen Mediterranean woodland																			
Olea europaea	10	90.9	12	92.3	11	84.6	7	87.5	24	64.9	19	30.6	1	6	50.0	13	100	12	48.0
Arbutus sp.	8	72.7	9	69.2	7	53.8	6	75.0	4	10.8	13	21.0	1	7	58.3	11	84.6	14	56.0
Quercus sp. evergreen	7	63.6	6	46.2	6	46.2	4	50.0	3	8.1	5	8.1		3	25.0	13	100	9	36.0
Phillyrea/Rhamnus	6	54.5	4	30.8	6	46.2	3	37.5	10	27.0	2	3.2		9	75.0	1	7.7	3	12.0
Pinus halepensis/P. brutia																2	15.4	3	12.0
Pistacia lentiscus							1	12.5			1	1.6				2	15.4	1	4.0
Deciduous Mediterranean woodland																			
Quercus sp. deciduous	11	100.0	13	100.0	11	84.6	6	75.0	24	64.9	42	67.7		9	75.0	12	92.3	12	48.0
Fraxinus sp.	2	18.2	4	30.8	2	15.4	1	12.5	6	16.2	10	16.1		1	8.3	1	7.7	1	4.0
Ostrya carpinifolia	1	9.1												2	16.7				
Carpinus sp.			1	7.7					2	5.4									
Open woodland and scrub																			
Pistacia terebinthus	2	18.2	2	15.4					1	2.7				1	8.3	2	15.4	4	16.0
Pistacia sp.	1	9.1							1	2.7						1	7.7		
Acer sp.									1	2.7									
Maloideae	4	36.4	2	15.4	1	7.7	2	25.0	4	10.8	7	11.3		2	16.7	10	76.9	11	44.0
Paliurus spina-christi									1	2.7									
Juniperus sp.	3	27.3	3	23.1	4	30.8	3	37.5	2	5.4				3	25.0			1	4.0
Amygdalus sp.	1	9.1							4	10.8	3	4.8							
Prunus sp.	1	9.1			2	15.4			2	5.4	1	1.6							
Clematis sp.			1	7.7												2	15.4		
Rosaceae																1	7.7		
Fabaceae	9	81.8	9	69.2	4	30.8	5	62.5	4	10.8	2	3.2		4	33.3	5	38.5	4	16.0
Erica sp.	2	18.2	2	15.4	4	30.8	5	62.5	1	2.7	1	1.6		1	8.3	7	53.8	4	16.0
Labiatae			3	23.1			1	12.5								1	7.7		
Cistus sp.			1	7.7												1	7.7	1	4.0
Mountain forests																			
Abies sp.			1	7.7	1	7,7			12	32.4	6	9.7	1	6	50.0	3	23.1	5	20.0
Abies/Juniperus									8	21.6						1	7.7		
Castanea/Quercus																5	38.5		
Pinus nigra/Pinus sylvestris	2	18.2	5	38.5	4	30.8	1	12.5	15	40.5	4	6.5		7	58.3	2	15.4		
Alluvial/Riverine/Brackish habitats																			
Corylus/Alnus											1	1.6							
Celtis sp.									1	2.7									
Ulmus sp.			1	7.7					2	5.4	1	1.6							
Ulmus/Celtis									2	5.4									
Platanus orientalis																		1	4.0
Populus/Salix			1	7.7					3	8.1	3	4.8				1	7.7	3	12.0
Ficus carica			3	23.1							1	1.6				1	7.7	1	4.0
Laurus nobilis									1	2.7						1	7.7		
Myrtus communis			2	15.4												3	23.1	1	4.0
Vitex agnus-castus			2	15.4					1	2.7	1	1.6				1	7.7		
cf. *Nerium oleander*																		1	4.0
monocotyledon	1	9.1												1	8.3				
cf. Chenopodiaceae	1	9.1																	
Tamarix sp.									1	2.7	1	1.6							
Cultivated																			
Vitis vinifera			2	15.4					3	8.1								2	8.0
cf. *Punica granatum*									1	2.7								1	4.0

Table 4.5 Ubiquity of identified wood taxa in samples from fills and burnt destruction layers from indoor contexts at Mitrou, Agia Paraskevi and Kynos.

pips, which includes 281 modern cultivars and 82 wild individuals (see Pagnoux et al 2015; Bouby et al 2021). This set of reference aims to be as representative as possible of the modern-day wild and domesticated grapevine. Previous studies have shown that carbonization causes a distortion of the pips (Logothetis 1970, 1974; Smith and Jones 1990; Mangafa and Kotsakis 1996). However, recent investigation on the effect of carbonization revealed that despite deformation, experimentally charred pips are correctly classified in the group of origin when they are compared to uncarbonized material (Ucchesu et al 2016; Bouby et al 2018).

Carbonized archaeological grape pips from Agia Paraskevi and Mitrou are thus compared to the uncarbonized reference collection mentioned above through Linear Discriminant Analysis (LDA), in order to be assigned to a predefined group (wild/domesticated compartment). The results of this morphological analysis are used here in order to provide an additional line of investigation of the diachronic interaction between human societies and plants in the area under study during the Bronze Age.

4.5 Results and interpretation

4.5.1 Wood charcoal. The plant list: overview

The results of wood charcoal analysis at the three Bronze Age sites are presented in Table 4.5. For comparison purposes between assemblages of different contextual provenance, i.e. fills and burnt layers, and chrono-cultural attribution, i.e. successive phases intra-site, as well as among different sites, the ubiquity of the identified taxa is shown (Table 4.5). Samples from destruction layers in indoor contexts reflect the uses of wood in construction and/or crafts but also debris of other uses (i.e. firewood remains on floors). Samples from fills and dumping areas are mostly long-term accumulations of firewood remains that were deposited through repeated cleaning of thermal structures. Nevertheless, accumulation of burnt wood remains reflecting other uses, such as carpentry waste and/or burnt timber, cannot be excluded. In multi-period settlements such as the ones presented in this study, levelling fills between successive building phases would have incorporated domestic fuel waste and occasionally burnt construction materials.

The list of taxa per site is rich. Evergreen and deciduous broadleaved taxa are present as well as several conifers. Twelve taxa are present at all sites and periods, the most ubiquitous being *Olea europaea*, deciduous *Quercus* sp. and *Arbutus* sp. Evergreen *Quercus* sp., *Phillyrea/Rhamnus*, Fabaceae and *Erica* sp. are frequently present at Mitrou in all periods, but less so at Agia Paraskevi and Kynos. *Fraxinus* sp., Maloideae, *Juniperus* sp. and *Pistacia* sp. are ubiquitous at all sites followed by *Pinus nigra/P. sylvestris* and *Abies* sp. *Populus/Salix* and *Vitis vinifera* are also frequently present at all sites. Several other taxa are variably present among different phases and sites (Table 4.5). Comparison between the data from fills and burnt layers at Mitrou does not indicate remarkable differences in the frequency of use of the different taxa either in the Early Bronze Age or in the Middle Bronze Age. Regarding the most ubiquitous taxa, the same frequency of use is attested in the fills and in the burnt indoor destruction layers. This is observed for both the taxa corresponding to trees such as *Abies*, *Pinus nigra/P. sylvestris*, *Quercus* sp. and *Olea europaea* as well as for bushy taxa such as Fabaceae and *Erica*. At Agia Paraskevi and Kynos the presence of the burnt remains of big trees such as *Abies* and *Pinus nigra/P. sylvestris* is more ubiquitous in the fills than in the burnt buildings. Nevertheless, at both sites, taxa of the understorey and scrub vegetation are more frequently present in the fills, probably reflecting their common use as kindling.

The variability of taxa observed through wood charcoal analysis may depend on contextual associations and origin of the samples and this aspect is investigated in the following sections.

4.5.2 Wood charcoal. Thermal structures

The results are presented in Table 4.6 showing that at all sites firewood use in hearths and ovens is characterised by a combination of tree and brushwood taxa. The hearth and ovens at Mitrou reflect the use of mostly *Olea europaea*, deciduous and evergreen *Quercus* and *Arbutus* alongside Fabaceae and *Erica*. The Early Bronze Age pit hearth at Mitrou is remarkable for a very high concentration of *Olea europaea* wood-remains. The hearth in the clay structure (NK145) of Phase 7 at Kynos presents a more varied taxonomic composition including several tree taxa in low frequency. Nevertheless, the main taxa used for fuel are again the above-mentioned Mediterranean evergreen trees, deciduous *Quercus* and the common brushwood taxa. Uncommon finds are *Populus/Salix* and *Vitis vinifera*, the latter probably having been used as kindling in the same manner as the brushwood mentioned above. The combination of *Populus/Salix* and *Vitis vinifera* in a hearth might also suggest the discard in the fire of useless/broken objects like baskets made of the flexible wood of willow or poplar alongside remains of their original content, grapevine bunches.

4.5.3 Wood charcoal. Fills and dumping areas: long-term accumulations of wood charcoal remains

Wood charcoal samples from fills and dumping areas originate from Early Bronze Age and Middle Bronze Age layers at Mitrou. Exterior areas (a street) are represented at Middle Bronze Age Agia Paraskevi while the material from a Late Helladic IIIC fill between phases 7 and 6 was

Cultural Period	EBA		MBA II				LBA	
	Mitrou						Kynos	
Feature	pit hearth		oven 63		oven 63		NK 145	
N samples	2		3		1		1	
N taxa	8		9		12		13	
Taxa	n	%	n	%	n	%	n	%
Evergreen Mediterranean woodland								
Olea europaea	74	82.2	7	25.0	56	25.0	4	7.7
Arbutus sp.	4	4.4	3	10.7	24	10.7	5	9.6
Quercus sp. evergreen	2	2.2	2	7.1	19	8.5	2	3.8
Phillyrea/Rhamnus	1	1.1	1	3.6	10	4.5		
Pinus halepensis/P. brutia					1	0.4	2	3.8
Deciduous Mediterranean woodland								
Quercus sp. deciduous	6	6.7	5	17.9	70	31.3	16	30.8
Open woodland and scrub								
Pistacia sp.			1	3.6				
Labiatae					2	0.9		
Maloideae	1	1.1			9	4.0	1	1.9
Juniperus sp.	1	1.1	1	3.6	1	0.4		
Fabaceae	1	1.1	5	17.9	21	9.4	2	3.8
Erica sp.			3	10.7	9	4.0	4	7.7
Mountain conifer forests								
Abies sp.							2	3.8
Castanea/Quercus							1	1.9
Pinus nigra/P. sylvestris					2	0.9		
Alluvial/Riverine/Brackish habitats								
Salix/Populus							11	21.2
Ulmus sp.							1	1.9
Cultivated								
Vitis vinifera							1	1.9
Total fragments identified			28	100	224	100	52	100
Quercus sp.							3	
angiosperm			5		6		1	
Total no fragments analysed	90	100	33		230		56	

Table 4.6 Results of wood charcoal analysis of assemblages from thermal structures: taxonomic composition, absolute and % fragment counts.

studied at Kynos (Table 4.2). The results are presented in Table 4.7. The list of taxa is rich at all three sites and the types of vegetation managed by the settlements quite diverse. Regarding the dominant taxa, these are variable among sites and successive periods. Deciduous *Quercus* dominates (40%) in the Early Bronze Age assemblage at Mitrou but in the Middle Bronze Age period it decreases significantly (18%) and is replaced by *Arbutus* (29.5%). At Middle Bronze Age Agia Paraskevi deciduous *Quercus* dominates (40%). At Late Bronze Age Kynos three Mediterranean evergreen taxa are the most abundant in the following order, evergreen *Quercus* (27%), *Olea europaea* (17%) and *Arbutus* (14%). Also, deciduous *Quercus* represents approximately 14% of the assemblage. Throughout the Bronze Age and at all different sites *Olea europaea* is the second most important firewood source (17-20%). Several other taxa are constantly present at all three sites in fluctuating frequency. *Phillyrea-Rhamnus*, *Fraxinus*, *Juniperus*, Maloideae and *Pistacia* were abundant alongside a variety of mixed evergreen/deciduous and understorey/open woodland components. Brushwood vegetation including Fabaceae, Labiatae, *Cistus* sp. and *Erica* was abundant and regularly used at all sites and throughout the Bronze Age.

Cultural Period	EBA		MBA		MBA		LBA	
Site	Mitrou				Agia Paraskevi		Kynos	
N samples	11		13		37		13	
Taxa	no	%	no	%	No	%	no	%
Evergreen Mediterranean woodland								
Olea europaea	109	17.5	102	20.8	80	19.8	56	17.0
Arbutus sp.	49	7.9	145	29.5	9	2.2	46	14.0
Quercus sp. evergreen	27	4.3	12	2.4	4	1.0	86	26.1
Phillyrea/Rhamnus	12	1.9	48	9.8	11	2.7	1	0.3
Pinus halepensis/ P. brutia							4	1.2
Pistacia lentiscus							3	0.9
Deciduous Mediterranean woodland								
Quercus sp. deciduous	254	40.8	87	17.7	161	39.9	45	13.7
Fraxinus sp.	3	0.5	2	0.4	17	4.2	1	0.3
Ostrya carpinifolia	1	0.2						
Carpinus sp.					2	0.5		
Open woodland and scrub								
Pistacia terebinthus	3	0.5			1	0.2	2	0.6
Pistacia sp.	4	0.6			1	0.2	1	0.3
Acer sp.					3	0.7		
Maloideae	16	2.6	1	0.2	9	2.2	28	8.5
Paliurus spina-christi					1	0.2		
Juniperus sp.	71	11.4	68	13.8	5	1.2		
Amygdalus sp.	1	0.2			5	1.2		
Prunus sp.	31	5.0	2	0.4	2	0.5		
Clematis sp.							8	2.4
Rosaceae							1	0.3
Fabaceae	32	5.1	13	2.6	4	1.0	8	2.4
Erica sp.	2	0.3	5	1.0	1	0.2	15	4.6
Labiatae							1	0.3
Cistus sp.							1	0.3
Mountain conifer forests								
Abies sp.			1	0.2	34	8.4	3	0.9
Abies/Juniperus					10	2.5	1	0.3
Castanea/Quercus							7	2.1
Pinus nigra/ Pinus sylvestris	5	0.8	5	1.0	24	5.9	3	0.9
Alluvial/Riverine/Brackish habitats								
Celtis sp.					1	0.2		
Ulmus sp.					3	0.7		
Ulmus/Celtis					2	0.5		
Populus/Salix					4	1.0	1	0.3
Ficus carica							1	0.3
Laurus nobilis					1	0.2	1	0.3
Myrtus communis							4	1.2
Vitex agnus-castus					1	0.2	1	0.3
monocotyledon	1	0.2						
cf. Chenopodiaceae	1	0.2						
Tamarix sp.					1	0.2		
Cultivated								
Vitis vinifera					3	0.7		
cf. *Punica granatum*					4	1.0		
Total fragments identified	622	100	491	100	404	100	329	100
Quercus sp.	17		10		16		10	
angiosperm	14		23				8	
bark	3		3				5	
unidentifiable	1							
conifer			3					
Total no fragments analysed	657		530		420		352	

Table 4.7 Absolute and % fragment counts of wood taxa identified in fills and dumping areas.

4.5.4 Wood charcoal. Interpretation of the results and aspects of the management of the local vegetation during the Bronze Age

The dataset points to the management of diverse habitats. Sclerophyllous woodland with *Olea europaea*, *Arbutus* and evergreen *Quercus* would have expanded along the narrow coastal fringe and would have characterised the immediate surroundings of all three sites. Mixed woodlands with sclerophyllous and deciduous trees (namely deciduous oaks, *Fraxinus*, *Carpinus* sp., *Ostrya carpinifolia*, *Acer* sp.) would have grown on mid altitudes overlooking the coast. Sun-loving trees and shrubs represented by *Cistus*, *Erica*, Labiatae, Fabaceae, *Juniperus* sp., *Pistacia terebinthus* and Maloideae would have developed in woodland clearings or would have formed scrubland at the interface between woodlands and farmlands. The vegetation of wetlands, water channels and brackish water is represented at all three sites by taxa such as *Platanus orientalis*, *Salix/Populus*, *Corylus/Alnus*, *Ulmus* sp., *Celtis* sp., *Myrtus communis*, *Tamarix* sp., *Vitex agnus-castus* and *Phragmites*. *Vitis vinifera* subsp. *sylvestris* could have been a climber in such riverine woodlands. Conifer woodlands with *Abies* and *Pinus nigra* would have covered the surrounding mountains. Although the management of these more distant resources is represented at all sites, the relative frequency of the representative taxa is higher at Middle Bronze Age Agia Paraskevi and Late Bronze Age Kynos compared to Early Bronze Age and Middle Bronze Age Mitrou.

Taking a closer look at the wood charcoal results from each settlement investigated in our paper, interesting aspects of the human-plant interaction in this part of mainland Greece are revealed. According to the archaeological evidence the Early Bronze Age II settlement at Mitrou was an important administrative center, like others of this period in mainland Greece (Van de Moortel and Zahou 2012, 1132). During the Early Bronze Age (Fig. 4.2), wood charcoal analysis at Mitrou indicates a balanced use of different vegetation types, especially the surrounding lowlands and foothills with olive,

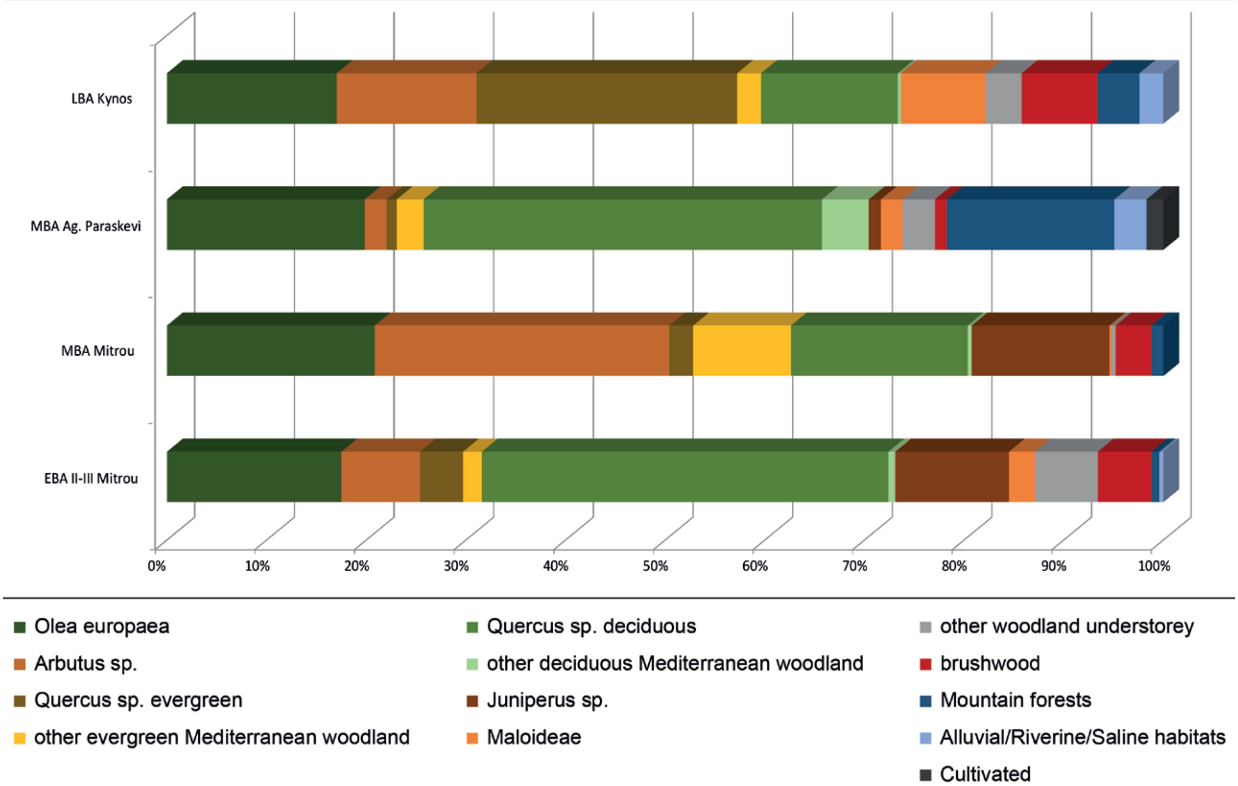

Fig. 4.2 Relative frequency of the most representative taxa and vegetation types in the three settlements in successive periods of the Bronze Age. Data based on the analysis of long-term accumulations of wood charcoal remains in fills and dumping areas.

sclerophyllous and deciduous woodlands. At Mitrou, the systematic use of olive wood both for fuel and construction timber suggests that already in the early 3rd mill BCE *Olea europaea* was an important feature of the local lowland vegetation. In the Middle Bronze Age, the wood charcoal results from Mitrou (Fig. 4.2) show the increase of *Arbutus*, *Juniperus* and brushwood at the expense of deciduous woodland. *Olea europaea* remained a stable source of firewood and timber. During this period, the previously flourishing Mitrou settlement had become a small village (Karkanas and Van de Moortel 2014, 202) and it may be suggested that the wood charcoal results reflect the expansion of maquis and scrub on abandoned farmland. Moreover, the reduced use of deciduous woodland resources may indicate concomitant shrinkage of the territory exploited by the settlement. Alternatively or in addition, one might argue that the observed reduction in deciduous woodland during the Middle Bronze Age at Mitrou and the expansion of maquis vegetation was the result of increasing human activity over time, during the course of the Early Bronze Age.

The Middle Bronze Age settlement of Agia Paraskevi was exploiting a diverse territory. Deciduous oak woodland, *Olea* and the coniferous forest of the nearby mountains were the major sources for firewood and timber. Activities in nearby marshland and the alluvial plain are reflected in the variety of woody taxa that would have grown in such habitats and were brought to the settlement. Fir and black pine were used for the construction of the buildings. However, an additional reason for the management of the coniferous mountain woodland might have been the demand for timber in shipbuilding, a potential commodity in the trading networks of the settlement and the settlement's access to the wider territory and rights to appropriate its resources. The pottery study indicates local production but also trade with areas to the north and south, while the direct contact of the settlement with the sea was probably the main factor of growing trade relations with other regions (Papakonstantinou et al 2015, 992-993).

The Late Bronze Age settlements at Mitrou and Kynos flourished during the 12th c BC. A remarkable aspect of the period is the high frequency of evergreen oak and *Arbutus* and the presence of *Pinus halepensis* in the Bronze Age dataset (Fig. 4.2). These characteristics probably reflect the progressive substitution of deciduous oak and mixed woodlands by these evergreen pyrophytes. According to our wood charcoal data, the beginning of the dominance of evergreen oaks and the spread of Aleppo pines in the

Cultural period	EBA	MBA		LBA		
Site	**Mitrou**	**Mitrou**	**Agia Paraskevi**	**Kynos**		**Mitrou**
No of samples studied	**18**	**48**	**40**	**26**	**14**	**21**
Level of analysis	**preliminarily studied samples**	**preliminarily studied samples**	**preliminarily studied samples**	**preliminarily studied samples**	**fully studied samples**	**fully studied samples**
Triticum monococcum (einkorn)	x	x	x	x	x	x
T. dicoccum (emmer)	x	x	x	x	x	x
T. timopheevii		? (em/tim)	x	x	x	x
T. spelta (spelt)						x
T. aestivum/durum (bread/macaroni)	x		x	x	x	x
Hordeum vulgare (barley)	x	x	x	x	x	x
Cicer arietinum (chick pea)				x	x	x
Vicia ervilia (bitter vetch)		x	x	x	x	x
Vicia faba var. *minor* (Celtic bean)		x	x	x	x	x
Lens sp. (lentil)	x	x	x	x	x	x
Lathyrus sativus/cicera (grass pea)	x	x	x	x	x	x
cf. *Pisum sativum* (pea)				x	x	
Papaver somniferum (opium poppy)			x	x	x	
Linum usitatissimum (flax)		x		x	x	x
Pistacia sp.			x			
Olea europea (olive)				x	x	
Camelina sp.				x		
cf. *Lallemantia* sp.				x	x	
Myrtus communis (myrtle)				x	x	
Ficus carica (fig)	x		x	x	x	x
cf. *Rubus* sp.			x			
Pyrus/Malus sp. (pear/apple)					x	
Vitis vinifera (grape pips and stalks)	x		x	x	x	x

Table 4.8 The presence of cereals, pulses, plants with oily seeds and fruit bearing species attested in preliminarily and fully studied assemblages at each site per cultural period. X indicates presence and the single question mark (?) identification in intermediate category.

coastal areas of eastern central Greece, may thus date to the 2nd mill BC. These characteristics would have been the result of long and repeated anthropogenic pressure on the vegetation coupled by a drying trend observed in the eastern Mediterranean after ca 4000 BC (Finné et al 2011, 2019; Weiberg et al 2019).

4.5.5 Plant macro-remains other than wood

Species presence, summarised for all sites per cultural period in Table 4.8, is based both on preliminary observations from scanned/sorted (Early Bronze Age Mitrou, Middle Bronze Age Mitrou and Agia Paraskevi, Late Bronze Age Kynos recent samples, see Table 4.4) and fully (Late Bronze Age Mitrou and first campaign Kynos samples, see Table 4.3 and Fig. 4.3) studied samples. Based on presence only, the following cereals have been identified at the three sites: *Triticum monococcum* (einkorn), *T. dicoccum* (emmer), *T. timopheevii*[1], *T. spelta* (spelt), *T. aestivum/durum* (bread/macaroni or free-threshing wheat) and *Hordeum vulgare* (barley). Of those, einkorn, emmer, bread/macaroni wheat and barley are attested at all three sites throughout the Bronze Age. Spelt wheat is encountered only once at Late Bronze Age Mitrou as a single glume base (Table 4.8, Fig. 4.3), while *T. timopheevii* glume bases have securely been identified at Middle Bronze Age Agia Paraskevi and both Late Bronze Age sites, Kynos and Mitrou (Table 4.8, Fig. 4.3). A wide range of pulses have also been identified in the assemblages: *Lens* sp. (lentil) and *Lathyrus sativus/cicera* (grass pea) are present in all the periods at all sites, *Vicia ervilia* (bitter vetch) and *Vicia faba* var. minor (Celtic bean)

1 Until recently known as "new type" glume wheat (Jones et al 2000; Czajkowska et al 2020).

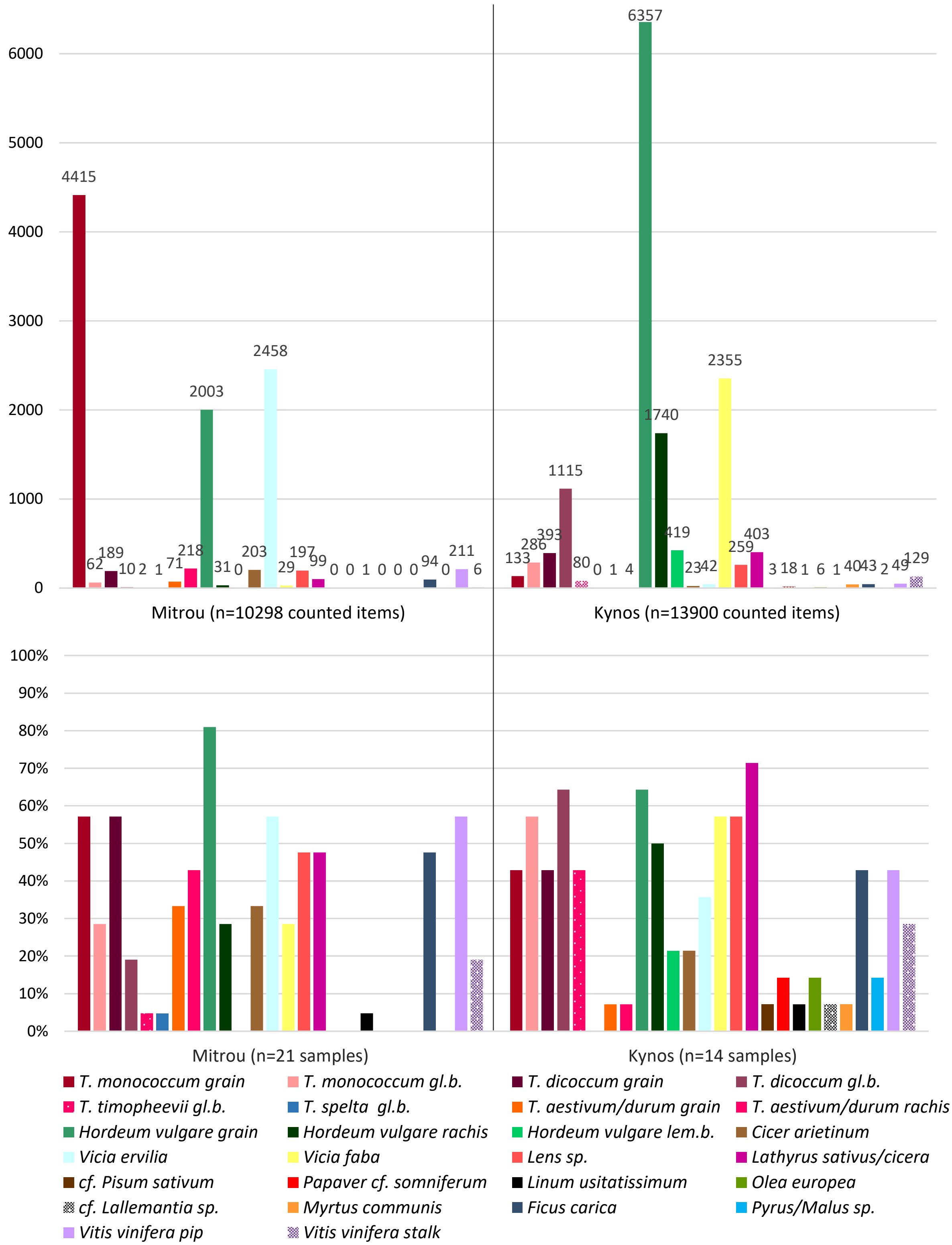

Fig. 4.3 Absolute seed/grain/chaff/etc numbers per species based on total numbers per site (top graph) and ubiquity of crop species present in the fully studied samples (bottom graph) from Late Bronze Age Mitrou (left) and Kynos (right).

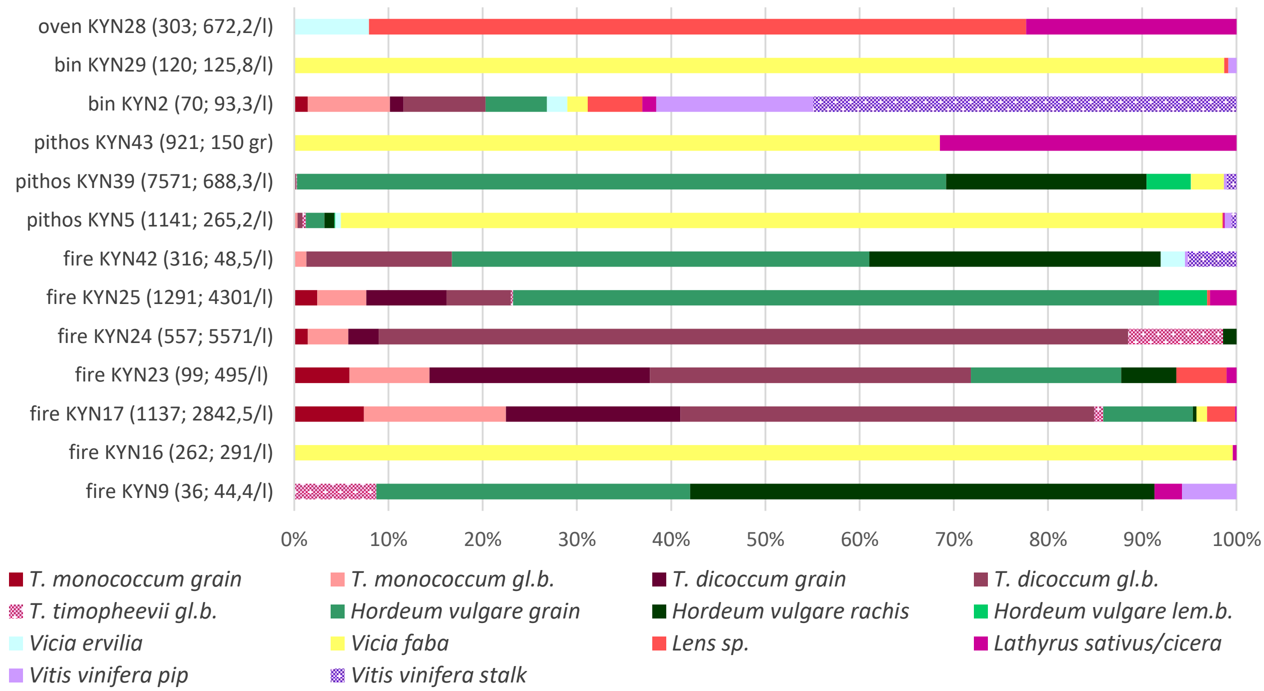

Fig 4.4 Chart showing the composition of each fully studied sample (with >20 counted crop/fruit items) from Kynos, expressing the relative proportions of all crop/fruit categories identified. Identification categories that never constituted more than 5% of the crop/fruit component at any sample were not included, namely *T. aestivum/durum* grain and rachis, *Cicer arietinum*, cf. *Pisum sativum*, *Ficus carica*, *Pyrus/Malus* sp., *Papaver somniferum*, *Linum usitatissimum*, *Olea europea*, cf. *Lallemantia* sp. and *Myrtus communis*. Intermediate/broad categories (e.g. *T. monococcum/dicoccum*, *Triticum* sp., *Vicia sp./Lathyrus sp.* etc) were also excluded. Total numbers of crop/fruit items and their density (items per litre of soil) per sample are given in parentheses.

are attested from the Middle Bronze Age onwards at all sites, while *Cicer arietinum* (chickpea) was identified only in the Late Bronze Age assemblages from both Kynos and Mitrou (Table 4.8, Fig. 4.3).

Contextual and quantitative data are available just for the two Late Bronze Age sites, Kynos and Mitrou (Karathanou in prep), and only these are further discussed here in terms of abundance and ubiquity (Fig. 4.3), as well as proportionate presence of crops/fruits in the different samples studied at each site (Fig. 4.4 and Fig. 4.5).

At Kynos the combination of extensive fire destruction episodes and judgment sampling yielded rather few albeit very rich (crop/fruit/wild totals per sample ranging between 67 and 11591 items) and dense samples (ranging between 88 and 20706 items per litre), mainly representing pure crop caches of barley grain and Celtic bean seeds either stored in clay vessels (*pithoi*) and bins (Fig. 4.4, samples KYN5, KYN29, KYN39) or found spilled in on-floor fire destruction debris (Fig. 4.4, sample KYN16). The above mentioned crops (barley and Celtic bean) were also found mixed with other crops at this site: Celtic bean has been found mixed with grass pea in another *pithos* sample (Fig. 4.4, sample KYN43), and barley grain has been found mixed with glume-wheat chaff and wild/weed seeds, and to a lesser extent pulses on various on-floor fire destruction samples (Fig. 4.4, KYN25 and KYN17 from the same floor context, and KYN9) and in a bin (Fig. 4.4, sample KYN2). In other samples, barley grain and chaff, were also mixed with rich glume wheat chaff concentrations and pulses (Fig. 4.4, samples KYN9 and KYN42). Emmer prevails over einkorn and *T. timopheevii* in most of these glume-wheat admixtures when absolute numbers are taken into consideration (Fig. 4.3 and in Fig. 4.4, samples KYN17, KYN25, KYN42), the exception being samples KYN9 where *T. timopheevii*, represented by chaff, is the only glume wheat present, and KYN2 where only einkorn and emmer are present in equal proportions (Fig. 4.4). Emmer also predominates in an emmer-einkorn spikelet concentration as indicated by the chaff to grain ratios and high density of crop remains, that was mixed with much less barley (grain and chaff), lentil and grass pea in a floor sample in close proximity to clay bins (Fig. 4.4, sample KYN23). In general, emmer seems to prevail among glume wheats at Kynos judging by the abundance and ubiquity of both grain and chaff remains (Fig. 4.3). Free-threshing wheat, identified as both grains and chaff, shows very low frequency of presence (7%, which corresponds to one sample) and

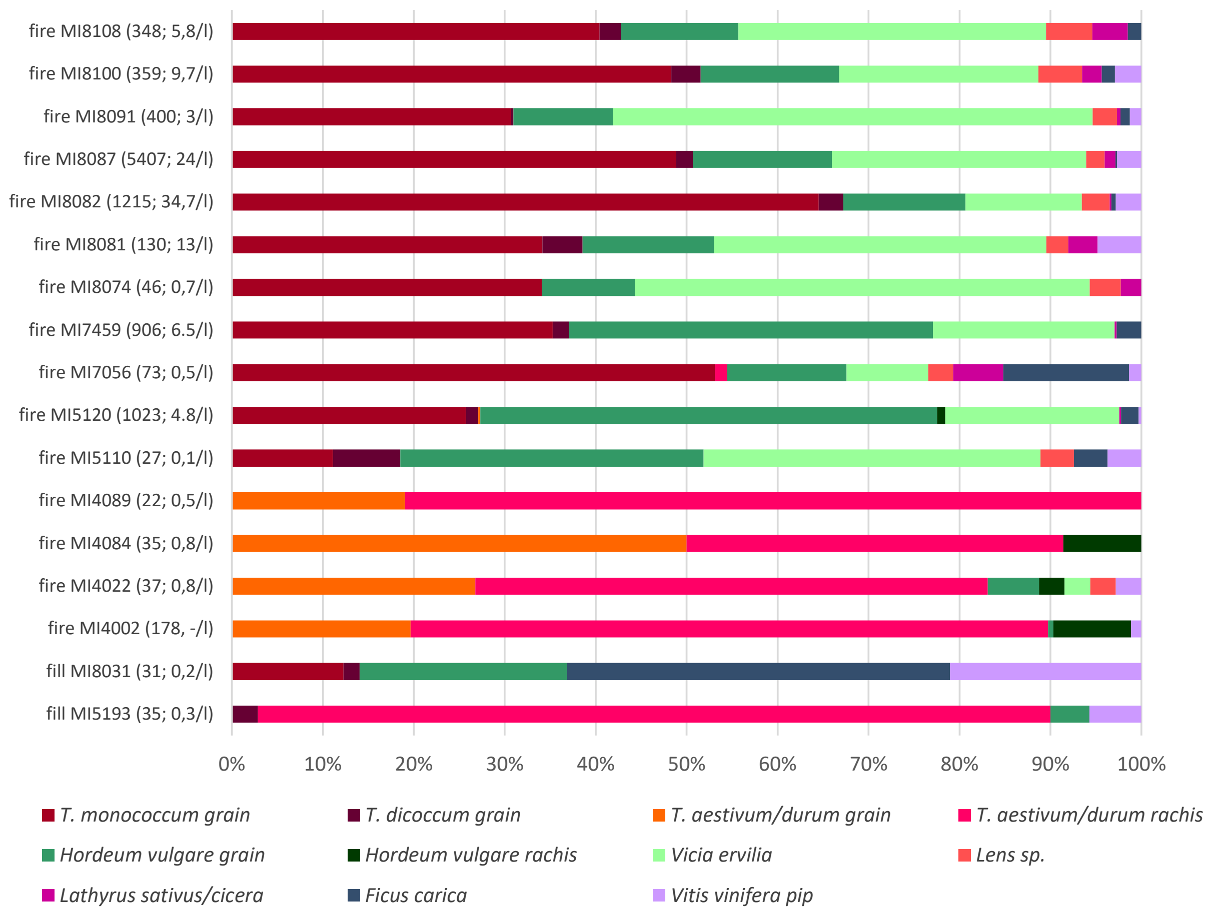

Fig 4.5 Chart showing the composition of each fully studied sample (with >20 counted crop/fruit items) from Mitrou, expressing the relative proportions of the crop/fruit categories identified. Identification categories that never constituted more than 5% of the crop component at any sample were not included, namely *T. monococcum*, *T. dicoccum*, *T. timopheevii* and *T. spelta* glume bases, *Cicer arietinum*, *Vicia faba, Linum usitatissimum, Vitis vinifera* stalk. Intermediate/ broad categories (e.g. *T. monococcum/dicoccum*, *Triticum* sp., *Vicia/Lathyrus* sp., etc) were also excluded. Total numbers of crop/fruit items and their density (items per litre of soil) per sample are given in parentheses.

absolute numbers (5 items in total) (Fig. 4.3). A small quantity of lentils mixed with grass pea and bitter vetch seeds were found in an oven (Fig. 4.4, sample KYN28). For all those mixed samples, it is difficult to assess separate or combined crop cultivation/processing and/or pre-/post-/depositional mixing.

The same lack of clarity as regards the formation processes that generated the archaeobotanical remains holds for the crop species attested at Mitrou as the sampled fire destruction layers were severely disturbed (Aleydis van de Moortel, pers. comm.). This, combined with the rather bulky sampling applied (sample volume ranging between 10 to 225 litres), produced several mixed but quite rich samples (crop/fruit/wild totals ranging between 48.5 and 6211.5 items), albeit of low density (0.3-41 items per litre), especially when compared to Kynos (see above). The most rich and dense of them, represent cereal grain and pulse seed concentrations. Einkorn, barley, and bitter vetch, all of high abundance and ubiquity (Fig. 4.3), are found as cleaned crops in these mixed grain/seed concentrations (Fig. 4.5, "fire" samples MI5110 up to MI8108). Emmer and einkorn have the same high ubiquity (Fig. 4.3), yet emmer, unlike einkorn, is present in low absolute numbers (Fig. 4.3 and Fig. 4.5). Although this might suggest at first sight that emmer was a crop contaminant of einkorn, the mixed composition of the samples calls for caution as regards such an interpretation. In addition to bitter vetch, grass pea and lentil, also present in these samples in various combinations (Fig. 4.5, "fire" samples MI5120 up to MI8108) were less ubiquitous and less numerous compared to bitter vetch (Fig. 4.3). Chickpea and Celtic bean despite not shown in Fig. 4.5 as they never constituted more than 5% of the crop/fruit component in any sample, were also present in ca 30% of the samples (Fig. 4.3). Unlike bitter

Fig 4.6 Charred olive remains from Late Bronze Age Kynos.

vetch for which we have strong evidence that it was a crop in its own right, the other pulse species we have identified were probably cultivated, yet we are unable to comment on their importance for the Mitrou inhabitants during the Late Bronze Age, nor can we exclude the possibility that some were mere contaminants of the other crops. At the same site, other floor and fill samples of even more mixed composition, are dominated by bread/macaroni wheat rachises and grain (Fig. 4.5, samples MI4002, MI4022, MI4084, MI4089, MI5193), both of which show quite high ubiquity values (>30%, Fig. 4.3). Free-threshing rachises are unlikely to accompany the glume wheat dehusking by-products in floor fills as the former are removed at early stages of the processing sequency. Thus, it is unlikely that they correspond to contaminants of the glume wheats; in all likelihood they were consumed as crops. The occurrence of free-threshing and glume wheat remains in the mixed floor fills resulted from complex taphonomy routes and multiple sources of origin (i.e. cooking accidents, chaff-and/or dung-consisting fuel remains, crop-processing residues, etc).

Regarding plants with oily seeds a wide range of species has been identified in the Middle and Late Bronze Age assemblages, all of which have a wide range of uses besides food including medicinal, hallucinogenic, aromatic and weaving: *Papaver* cf. *somniferum* (opium poppy), *Linum usitatissimum* (flax), *Pistacia* sp., *Olea europaea* (olive), *Camelina* sp., cf. *Lallemantia* sp. and *Myrtus communis* (myrtle) (Table 4.8, Fig. 4.3). *Pistacia* sp. is present only at Agia Paraskevi (Table 4.8; Gkotsinas et al 2014) while the latter four (olive, *Camelina* sp., cf. *Lallemantia* sp., myrtle) have so far been identified only in the Late Bronze Age, namely at Kynos (Table 4.8, Fig. 4.3). Of those four, only myrtle has been found in a small concentration of 40 seeds inside a barley-containing *pithos* (Fig. 4.3). Olive stones, in some cases whole or in halves (Fig. 4.6), and cf. *Lallemantia* sp. occur only sporadically at Kynos (Fig. 4.3), though this picture is likely to change once all of the samples are fully studied. Likewise, flax and opium poppy seeds are rarely found among the Middle Bronze Age assemblages of Mitrou and Agia Paraskevi respectively (Table 4.8; Gkotsinas et al 2014). Flax and opium poppy are also very rare at Kynos (Fig. 4.3, see also Kounouklas et al 2021).

Finally, *Ficus carica* (fig), *Rubus* sp., *Pyrus/Malus* sp. (pear/apple) and *Vitis vinifera* (grape) represent the fruit identified throughout the Bronze Age (Table 4.8). Fig (represented by druplets at all sites and only at Late Bronze Age Mitrou by few potential flesh fragments too) and grapevine remains (pips and stalks), are both continuously present since the Early Bronze Age (Table 4.8). In the Late Bronze Age, they are the most ubiquitous and dominant fruits in the studied samples (Fig. 4.3). At Mitrou, grape and fig occur in ca 50% of the samples (Fig. 4.3) from both fills and on-floor fire destruction layers (Fig. 4.5), indeed dominating a fill sample of a rather mixed composition (Fig. 4.5, sample MI8031). At Kynos, both fruits are present in nearly half of the samples but fig druplets are far less abundant than grape, the latter represented by more stalks than pips (Fig. 4.3). Grape, though usually present in small quantities in all kinds of contexts sampled at this site (KYN29 from bin, KYN5 and KYN39 from *pithoi*, KYN9 and KYN42 from on-floor fire destruction layers, Fig. 4.4), dominates a rather mixed in composition bin sample (Fig. 4.4, sample KYN2). *Rubus* sp. and *Pyrus/Malus* sp. on the other hand, are rarely attested at Middle Bronze Age Agia Paraskevi (Table 4.8) and Late Bronze Age Kynos (Table 4.8, Fig. 4.3) respectively.

A long list of wild plant taxa have already been identified in the assemblages, while analysis is ongoing. Certain among them, like *Lolium* sp., *L. temulentum* and *Buglossoides arvensis,* all so far identified in the two Late Bronze Age sites and Middle Bronze Age Agia Paraskevi (*Lolium* sp.), are considered typical weeds growing on arable land. At Mitrou, both *Lolium* sp./*L. temulentum* and *B. arvensis* were found in nearly all the mixed cereal grain- and pulse seed-rich on-floor concentrations (namely "fire" samples MI5110 up to MI8091 and MI8108, Fig. 4.5), suggesting their potential association with any of the crops identified at the site. In the fully studied samples from Kynos, *Lolium* sp. and *Lolium temulentum* occur in association with barley (Fig. 4.4, sample KYN39) and Celtic bean (Fig. 4.4, sample KYN5) in certain storage concentrations (see above). As the study of wild/weed taxa is in progress, only a coarse resolution of the areas represented in the samples that could point to habitats beyond fields or to usual field conditions (e.g. fields potentially waterlogged at times of the year), can be provided here. For instance, certain taxa we have identified are indicative of wet and dry/rocky grassland/pasture habitats (Table 4.9). Caution is needed however, as many among the taxa listed in the relevant table have a wide range of habitats and besides being harvested with crops as weeds they could have been grazed by domestic animals, ending in their dung which could have been used

Species/Genus	Habitat	Site
Carex sp.	wet/marshes	LBA Mitrou
Cladium mariscus	wet/marshes	LBA Mitrou
Cyperaceae	wet/marshes	MBA Agia Paraskevi and LBA Mitrou
Eleocharis sp.	wet/marshes	LBA Mitrou
cf. *Schoenus nigricans*	wet/marshes/sandy areas by the sea	LBA Mitrou
Alkanna sp.	open dry grassland/hills and mountains	LBA Mitrou
Echium sp.	open dry grassland	LBA Mitrou
Hypericum sp.	open dry grassland/rocky pasture/hills and mountains/rocky terrain	LBA Mitrou

Table 4.9 Wild non-wood plant species/genera/families identified so far in the preliminarily/fully analysed assemblages tabulated according to major habitat preferences (i.e. wetland and dry/rocky grassland/pasture).

Cultural Period	Site	Total number of grape pips	Wild	Domesticated	Non allocated	% Wild	% Domesticated	% Non allocated
MBA	Agia Paraskevi	77	50	17	10	64.9%	22.08%	12.99%
LBA	Mitrou	89	32	49	8	36.0%	55.06%	8.99%
Total		166	82	66	18	71.0%	20.11%	8.91%

Table 4.10 Number of pips allocated to the wild and domesticated compartment.

as fuel (cf. Valamoti 2004). At present, we cannot exclude the possibility that some of the Late Bronze Age samples may have contained dung-derived material that could have contributed some at least of these wild/weed taxa in the samples studied here. Dung was used to manure certain Late Bronze Age crops as recent isotopic analysis of einkorn, emmer and barley grains from Kynos has indicated (Styring et al. 2022).

4.5.6 Morphometric study of Vitis remains: an attempt to identify wild vs cultivated grapevines in the landscape

Of the 166 archaeological grape pips that have been compared to the modern reference collection mentioned above, 82 grapes pips (71%) have been classified as wild, 66 (20.11%) as domesticated and 18 (8.91%) cannot be classified with a posterior probability ≥ 0.75, which we consider as reliable (Table 4.10).

Grape pips from Middle Bronze Age Agia Paraskevi are mostly classified as wild (64.9%), but quite a high proportion of the assemblage (22.08%) is assigned to the domesticated compartment. Domesticated morphotypes are dominant at the later site, Late Bronze Age Mitrou (55.06%), but a significant part of the grape pips is classified as wild (36%).

4.6 Discussion

Archaeobotanical studies at Agia Paraskevi, Kynos and Mitrou, the three Bronze Age settlements, provide insights as regards the management of the landscape through the opening up of fields, orchards and pastures as well as the procurement of natural woody resources for fuel and crafts. Our research sheds light into diverse economic activities carried out in relation to crop cultivation and wild plant management and/or procurement as well as the long-term effects of human activity in a well-defined area sharing similar general environmental conditions, at the same time displaying variability as regards proximity to the coast and altitude. Thus, our approach allows the characterisation of vegetation in different parts of the landscape used by the different communities studied here during the course of the Bronze Age.

Throughout the Bronze Age, a variety of cereal and pulse crops appear to have been cultivated. Glume wheats (einkorn, emmer and *T. timopheevii*) and barley were favored in the area, but free-threshing wheat may have been less important. The status of *T. spelta* cannot be assessed on the available data. It is of interest to note the absence of millet among the cereal remains from the sites examined here, a cereal species that appears at several northern Greek sites of the Late Bronze Age and perhaps even earlier. This crop may have not been of interest to the prehistoric farmers of the region, reinforcing suggestions that millet might have been an identity signifier in the Bronze Age Aegean (Valamoti 2016, 2017, 2023). Alternatively, it might have been cultivated, yet, its remains may have been associated with other types of sites not investigated yet archaeobotanically, e.g. farmsteads. Celtic bean, bitter vetch, and lentil were certainly cultivated, but the status of grass pea and chickpea is more obscure. It would not be safe, however, to assume that chickpea was a crop as this species is nearly absent from the Neolithic and Bronze Age of Greece (Valamoti 2009).

In addition to crop-fields, fruit trees were harvested at all sites and both wood charcoal and fruit remains of the grapevine, olive and fig suggest that these trees were managed by the Bronze Age communities we have investigated archaeobotanically. Tree-cultivation of pomegranates is for the moment a hypothesis based on few charred wood remains attributed to cf. *Punica granatum* at Agia Paraskevi and Kynos.

The grapevine finds and especially the morphometric analysis has revealed that at Agia Paraskevi domesticated grapevines were being cultivated. This, on the basis of our current knowledge, together with evidence from Middle Bronze Age Tsoungiza (Allen and Forste 2020; Bonhomme et al this volume) is the earliest evidence of the domesticated type in the Aegean. Given the wider context of early grapevine use in Greece, a local process of domestication is very likely and would be undetected in grape-pip morphology for a certain period of time during which grapevines were cultivated but pips did not morphologically change (cf. Dikili Tash and P.O.T.A. Romanou, Valamoti 2015; Valamoti et al 2020; Pagnoux et al 2021). Indeed, this ongoing and incipient process is perhaps reflected here by the high proportion of morphologically wild pips from Agia Parakevi and Late Bronze Age Mitrou. However, management of grapevines (pruning, harvesting) in the wild cannot be excluded, especially since grapevines could have been growing close to Agia Paraskevi, in the alluvial woodlands and marshes which are well-documented in the wood charcoal assemblage from the site. In addition, trade networks and contacts with other regions could have contributed stock of grapevine varieties from other parts of the Aegean and beyond (cf. Pagnoux et al 2015). Although local processes cannot be excluded, more archaeobotanical evidence from earlier periods is needed to investigate a local process or an introduction from elsewhere.

Fig tree harvesting is represented almost exclusively by druplets and isolated wood charcoal remains. The only exception is Late Bronze Age Mitrou where few potential flesh fragments were attested. Figs were indeed consumed by humans as has been suggested elsewhere by the caches of whole fig fruits found for example at Neolithic Dikili Tash (Valamoti 2015) and Late Bronze Age Kakovatos (Kotzamani 2011) amongst others, while they could be fed to animals in certain cases (cf. Valamoti 2004). Wood charcoal remains are few but constant. Although fig tree wood is an unpleasant smoke producing fuel when green and unseasoned, it could have been used in such state for smoking and/or smudge fires when necessary.

The case of the olive, based on our study, is particularly interesting. The wood charcoal dataset provides the earliest direct evidence for the abundant local presence of *Olea* in the mid-3rd mill BC mainland Greece, similar to finds from the Cyclades or Crete (Valamoti et al 2018). The abundant and frequent use of olive wood at Mitrou is unprecedented in the Holocene wood charcoal record of southern mainland Greece. The new data contrast the absence of olive during the Early Neolithic around Sarakenos Cave in Boeotia (Moskal-del Hoyo and Ntinou 2016) and its sparse presence in other Early to Final Neolithic sites in the Peloponnese (Valamoti et al 2018). Since the early 3rd mill BC, olive characterised the local lowland vegetation of the area and/or was cultivated in parts of the landscape dedicated to this end. Its wood was systematically used and olive remained a stable source of firewood and timber throughout the Early and Middle Bronze Age in the study area. We suggest that this stability in an otherwise changing vegetation setting most probably reflects the cultivation of the olive. Nevertheless, there is as yet no evidence for the use of its fruit in preliminary analysis of non-wood archaeobotanical remains of the Early and Middle Bronze Age. It is only in the Late Bronze Ages that olive stones appear at Kynos.

Wood charcoal analysis points to diverse habitats and types of vegetation located close to the sites or at some distance from them developing in succeeding altitudinal zones and/or in different ecological niches (Table 4.4 and 4.6, Fig. 4.2). The wood charcoal dataset from the three sites reflects the management of a wide range of woodland resources. Mixed evergreen and deciduous woodlands and brushwood were the source for fuel and timber. More distant resources, such as the coniferous woodlands on the mountains were also managed for timber uses in construction and probably shipbuilding or maritime exchanges. During the 3rd mill BC deciduous oak was a dominant component of mixed thermophilous woodlands in eastern central Greece. Other thermophilous taxa such as evergreen oaks and Aleppo pines became prominent elements of the coastal areas of the region probably not earlier than the 2nd mill BC as reflected in their abundance in the Late Bronze Age compared to their low relative frequency in the Early and Middle Bronze Age. The latter observation may be seen in correlation with the increase of *Arbutus* in the Middle Bronze Age, probably reflecting the gradual opening of the mixed woodland canopy and the expansion of Ericaceae as a result of farming and grazing activities. In line with such processes are the wild taxa, *Alkanna* sp., *Echium* sp., and *Hypericum* sp. identified in the Late Bronze Age Mitrou that primarily thrive in open dry grasslands and often rocky terrain (Table 4.9).

Wetlands would have existed around the sites and are reflected both in wood charcoal analysis and the preliminary results of the wild seeds analysis. The presence of alluvial woodlands and Mediterranean riverine vegetation (*Salix/Populus, Platanus orientalis, Alnus, Ulmus, Vitex agnus-castus, Myrtus communis, Laurus nobilis*) and/or brackish habitats (*Tamarix*, Chenopodiaceae) is testified at all three sites. This picture is enriched by the presence of wet-loving plants at Agia Paraskevi (Cyperaceae), while at Mitrou aside from the generally wet places (*Carex* sp., Cyperaceae), shallow waters/marshes (*Eleocharis* sp., *Cladium mariscus*) and potentially sandy places near the sea (cf. *Schoenus nigricans*) would have been present. The existence of such habitats at both prehistoric sites has been proved by the palaeogeographical investigations (Vouvalidis et al 2010; Green 2012) and is further supported by aquatic faunal evidence at Agia Paraskevi (Syrides 2008; Gkotsinas et al 2014). All the above suggest that seasonal lakes, marshes and/or saltmarshes existed in the surroundings. Such habitats would have provided building material or plants for making mats and baskets, some might have been grazed by domestic animals, their dung subsequently burnt at the sites; we cannot exclude the possibility, however, that some of the crop fields were in parts seasonally waterlogged.

Although agricultural and arboricultural activities appear to have been constant over time in the investigated region, it is through the anthracological evidence that we have indications for a reduction, over time, of deciduous woodland vegetation and changes in woodland composition in the proximity of the sites. Moreover, the exploitation of arboreal vegetation from further upland is more conspicuous in the Middle and Late Bronze Age compared to the Early Bronze Age. These observations are in agreement with the socio-economic activities of the three communities we have investigated here. The arable parts of the landscape were exploited through the cultivation of cereals and pulses, evidenced through the wide range of species identified in the assemblages of the Bronze Age. Tree crops, on the other hand, like the olive and the grapevine, may well adapt in lands far less suited for the cultivation of cereals and pulses (cf. Renfrew 1972). As Colin Renfrew argued in his influential work (1972), in the Early Bronze Age the Mediterranean triad (wheat, olive, vine) allowed the diversification of the lands used for cultivation of different crops, olives and grapevines, which would have led to the need for redistributive centers. The settlements presented in this study became important centers in their respective territories at different periods throughout the Bronze Age. There is evidence for intense building activity and spatial organization, large storage facilities and trade with other areas. Undoubtedly, the coastal location of all three sites played an important role in the networks connecting the hinterland with the Aegean through the north Euboean Gulf. In this line, agricultural production, tree-crops and abundant timber resources would have been commodities managed, stored and traded by the communities investigated here. In such a context and on the basis of our results we suggest that an additional product of the lands managed by the settlements would have been the coniferous woodlands. Such resources would have been highly valued in Bronze Age shipbuilding and maritime activity.

4.7 Conclusions

Our integrated approach towards human-plant interaction during the Bronze Age in a well-defined area of East-Central Greece has allowed us to observe continuity and change over time in a resolution much finer than attempted before for Greek prehistoric sites. Archaeobotanical macro-remains including wood charcoal, combined with morphometric analyses of grape-pips have allowed us to reconstruct patches of managed and wild vegetation in the landscape: fields of a wide range of cereals and pulses, some more demanding than others in terms of nutrients and moisture, fields of oil-crops and beyond or amidst this cultivated land, areas where fruit was grown. Although olive trees, fig trees and grapevines could have grown also in the wild, it is most likely that during the period we have studied the remains of fruit we have identified originated from orchards where fruit trees were grown. The grapevines were either imported to the area or locally domesticated, something that we hope will be clarified in the future with more data from the region. We have observed, however, an increasing predominance of the domesticated type that suggests a systematic cultivation during the Bronze Age that led to increasingly domesticated-looking grape-pip morphotypes. Olive cultivation was also significant in our study area, thus expanding the locations of known olive cultivation in Greece during the Bronze Age. Beyond the managed landscape for plant cultivation, areas where animals potentially grazed, including marshland, have been identified through wild plant taxa of herbaceous and arboreal vegetation. Moreover, in addition to the lowlands and low hills where fields and orchards would have been located, human activity in higher altitudes has been demonstrated through the remains of wood charcoal. We believe that this first attempt towards an integrated approach of plant use and land management over a long period of time has highlighted the significance of such studies for a better understanding of past human-environment interaction and will be applied in the future to other parts of Greece, covering longer time periods.

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Chapter 5

Staple grains in the later Bronze Age of the (southern) Aegean: archaeobotanical, textual and ethnographic insights

Paul Halstead, Amy Bogaard, Glynis Jones

Abstract

The importance of staple grains to the "palatial" political economies of the southern Aegean later Bronze Age is evident in Minoan monumental storage facilities and Mycenaean written records of ration distributions. Charred crop remains show that multiple cereal and pulse taxa were cultivated in the later Bronze Age and consumed in various forms (e.g. split pulses/groats, flour). In contrast to this diverse archaeobotanical record, Mycenaean (and, perhaps, earlier Minoan) texts document only two (possibly three) cereal types and no pulses, posing questions as to which cereals were selectively recorded and why. The form of Mycenaean ideograms *120 and *121 offers only slender support for their conventional identification as (emmer) wheat and (six-row hulled) barley, respectively, while Palmer's proposed reversal of these attributions rests on questionable assumptions regarding the range of cereals grown, their growth habits and their relative value. It thus remains unknown which cereal taxa (or, perhaps, stages of processing) are represented by the ideograms, but the latter's contrasting contextual associations imply intriguing differences in cultural value.

In traditional Mediterranean food cultures and likewise in Classical antiquity, a widespread hierarchy of staple-grain values had considerable cultural and practical significance, highlighting the importance of determining whether grains were similarly ranked in the prehistoric Aegean. To this end, we explore archaeobotanical evidence for the care invested in growing different taxa or preparing them for consumption. While evidence for food preparation methods is as yet sparse, stable carbon and nitrogen isotope analyses have identified some fairly striking contrasts between taxa in intensity of husbandry, but which crops were "favoured" by high investment was locally variable. As yet, therefore, Neolithic and Bronze Age grain crops in the Aegean exhibit no evidence of a widely consistent hierarchy of value, comparable with that known from Classical antiquity and recent times.

Keywords: *barley, wheat, palaces, Mycenaean, Minoan, food, fodder, texts, charred remains, $\delta^{13}C$, $\delta^{15}N$*

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5.1 Introduction

Staple grains occupy an important place in understanding of the "palatial" societies of the southern Aegean later Bronze Age (2nd mill cal BC). Written records in Linear B script from the 14th-13th c BC Mycenaean palaces list grain rations to dependent craft workers (Godart 1968; Palmer 1989) who played a central role in the wider political economy (Killen 2008). Sparser records in Cretan Hieroglyphic and Linear A scripts from the preceding Minoan palatial period may reflect a similar role for staple grains (e.g. Palmer 1995; 2008; Uchitel 2007), which were also doubtless the dietary mainstay for the rest of the later Bronze Age population including (with richer accompanying dishes – Isaakidou 2007) the elite. Production (e.g. Killen 1995; 1998; Halstead 1999; Nitsch et al 2019; Whitelaw 2019), storage (e.g. Branigan 1987; Strasser 1997; Halstead 1997; Christakis 2008; Privitera 2014) and distribution (e.g. Renfrew 1972; Halstead and O'Shea 1982) of these grains have accordingly figured prominently in debates on the functioning and origins of these palatial societies, and also of their less hierarchical counterparts in northern Greece (e.g. Jones et al 1986; Andreou 2010, 650; Nitsch et al 2017).

Although the monumental storage facilities of the Minoan palaces attracted more attention, charred remains of staple grains were reported from early excavations at Knossos, Malia and elsewhere (Halstead 1992, 108, table 1), in some cases identified by local workmen. The latter, although farmers, lacked first-hand experience of glume wheats (einkorn, emmer and spelt – Gennadios 1914, 878) and perhaps used unfamiliar folk names for some pulses, so early reports lack precision and reliability. Analysis of more recent finds by archaeobotanists has broadened the range of species attested by charred grain, but which of these are recorded in Minoan and Mycenaean texts is uncertain.

Here we first summarise available archaeobotanical evidence for the cereal and pulse grains consumed in later Bronze Age Greece, including the non-palatial northern mainland where such research has been most intensive. We then turn to Bronze Age written records of staple grains and their problems of interpretation, before exploring the wider significance of apparent contradictions between archaeobotanical and textual evidence.

5.2 Cereal and pulse crops of later Bronze Age Greece: archaeobotanical evidence

Establishing from charred remains which grain crops were consumed is not unproblematic. First, a species might be present in a particular context, but only as a minor contaminant of another cultivar, so distinction must be attempted between species found as more or less pure concentrations (or major components of a mixed concentration) and those found only as scattered specimens (e.g. Halstead 1994, 204-205 table 7.1; Livarda and Kotzamani 2013, 8-9 table 2; Valamoti 2023). Secondly, because grain is preserved by charring only when burnt under suitable conditions, while its systematic recovery and specialist analysis are relatively recent developments in Greece (e.g. Livarda and Kotzamani 2013, 6 figs 4-5), the archaeobotanical record is patchy. The breadth of species identified by systematic studies of rare, well-preserved burnt storerooms at the Knossos Unexplored Mansion on Crete (Jones 1984), the West House at Akrotiri on Santorini (Sarpaki 1992) and Assiros Toumba in Macedonia (Jones et al 1986; Heaton et al 2009) highlights how incomplete is the evidence for most sites/phases. Accordingly, we adopt here a regional and chronologically coarse approach that distinguishes: for Crete and the Cyclades, the Old and New (Minoan) Palace from the Final (Mycenaean) Palace and Post-palatial periods; and for peninsular Greece, the Middle-early Late Bronze Age from the later Late Bronze Age (Late Helladic III), corresponding to the pre-palatial and the Mycenaean palatial (and immediately post-palatial) periods, respectively, of the southern and central mainland.

Based on charred concentrations reported by specialist archaeobotanists (Table 5.1), the range of grain crops in northerly Macedonia included seven cereals and four pulses: free-threshing bread or macaroni wheat (*Triticum aestivum* or *T. durum*), emmer (*T. dicoccum*), einkorn (*T. monococcum*), spelt (*T. spelta*) and *T. timopheevii* (previously known as "new" type glume wheat – Czajkowska et al 2020), six-row hulled barley (*Hordeum vulgare*), common millet (*Panicum miliaceum*), lentil (*Lens culinaris*), Celtic bean (*Vicia faba*), bitter vetch (*V. ervilia*) and grass pea (*Lathyrus sativus*). For the southern and central mainland (including Thessaly), confirmed crops include at least five cereals and three pulses: free-threshing bread/macaroni wheat, the glume wheats emmer and einkorn, both hulled and naked six-row barley, lentil, Celtic bean, and bitter vetch. Crops on Crete included at least three cereals and five pulses: free-threshing wheat, emmer wheat, six-row hulled barley, lentil, Celtic bean, bitter vetch, grass pea, and winged vetchling (*Lathyrus ochrus*). In the Cyclades, contemporary with the Minoan palaces, two cereals and three pulses were identified among partly processed grains in the West House at Akrotiri: six-row hulled barley, einkorn wheat, lentil, pea (*Pisum sativum*), and Spanish vetchling (*Lathyrus clymenum*).

Some regional and chronological variation may be detectable: common millet was established in Macedonia, but probably not further south (Valamoti 2016) where severe summer drought is unfavourable to its growth; of the glume wheats, spelt originated in and spread from temperate Europe (Stika and Heiss 2013, 360) and is also apparently limited to Macedonia, where einkorn, too, is

Site	Period	Free-threshing wheat	Einkorn	Emmer	Timopheev's wheat	Spelt	Hulled barley (6-row)	Naked barley (6-row)	Common millet	Lentil	Pea	Celtic bean	Bitter vetch	Grass pea	Winged vetchling	Spanish vetchling	Source
CRETE																	
Monastiraki 2	OP									X?							Livarda and Kotzamani 2013
Kastelli Chania	NP						X					X		X			Sarpaki 2016
Myrtos Pyrgos	NP						X						X				Livarda and Kotzamani 2013
Sissi	NP													X			Livarda and Kotzamani 2013
Ourania	NP	X					X			X		X					Livarda and Kotzamani 2013
Knossos Unexplored Mansion	FP	X		X			X					X		X	X		Livarda and Kotzamani 2013
Palaikastro	PP											X					Livarda and Kotzamani 2013; MacGillivray et al. 1989, 435-436
CYCLADES																	
Akrotiri	NP		X				X			X	X					X	Sarpaki 1987; 1992
S-C MAINLAND																	
Agia Paraskevi	MH	X	X	X			X										Gkotsinas et al. 2014
Argissa	MB						X	X									Halstead 1994
Lerna	MH						X			X		X					Halstead 1994
Marmariani	MB			X													Halstead 1994
Pevkakia	MB		X				X										Halstead 1994
Tsani	MB						X										Halstead 1994
Thebes	early LH											X					Halstead 1994
Gla	LH III		X														Halstead 1994
Iolkos	LB						X					X					Halstead 1994
Mycenae	LH III			X			X						X				Hillman 2011
Tiryns	LH III												X				Halstead 1994
MACEDONIA																	
Toumba Thessalonikis	MB		X	X			X			X		X	X	X			Nitsch et al. 2017; Valamoti 2023
Archontiko	early LB	X	X	X	X	X	X		X	X		X	X	X			Nitsch et al. 2017; Valamoti 2023
Angelochori	late LB						X										Valamoti 2023
Assiros Toumba	late LB	X	X	X	X	X	X		X	X			X				Heaton et al. 2009
Dimitra	late LB			X													Valamoti 2023
Kastanas	late LB		X	X					X				X				Halstead 1994
Toumba Thessalonikis	late LB		X	X			X		X				X				Nitsch et al. 2017; Valamoti 2023

Table 5.1 Archaeobotanical evidence for cereal and pulse crops in later Bronze Age Greece*.
* listed crops = taxa represented as dominant components of stores or other concentrations of charred grain. Period: OP Old Palace; NP New Palace, FP Final Palace, PP Post-palatial, MB (MH) Middle Bronze Age (Middle Helladic), LB (LH) Late Bronze Age (Late Helladic).

particularly well represented (as in the Neolithic); naked barley, present into the Middle Bronze Age at least in central Greece, thereafter apparently disappears, consistent with results elsewhere in Europe (Stika and Heiss 2013, 359-360). Otherwise, paucity of data may account for apparent regional and temporal variation in the range of staple crops, not least on Crete where "wheat", "barley" and various pulses in early reports (Halstead 1992, 108 table 1) may have included additional species. Nevertheless, throughout later Bronze Age Greece, staple grains evidently included multiple cereal and multiple pulse species. The grains consumed by southern palatial societies (and, in several cases, stored within the palaces) included several pulses and *at least three* cereals – a type of free-threshing wheat, a glume wheat (usually emmer) and six-row hulled barley. Also relevant is the form in which grains were stored. Archaeobotanical evidence from burnt storage contexts, at Assiros Toumba (Jones et al 1986) in Macedonia, and at Mycenae (Hillman 2011) and Knossos (Jones 1984) in the palatial south, suggests that pulses and free-threshing wheat were stored as free grain, whereas glume wheats and hulled barley were kept in their protective husks or hulls. In preparation for consumption, however, the glume wheat husks and perhaps the barley hulls would be removed, while both cereals and pulses might be reduced to broken groats/"split peas" or flour (e.g. Sarpaki 1992; Jones and Halstead 1993; Valamoti 2011; Valamoti et al 2011; 2019) and were sometimes stored in these forms, at least in the short term, as at Macedonian Archontiko (Papanthimou et al 2013) and Cycladic Akrotiri (Sarpaki 2001). Culinary preparation thus expands the range of grain commodities potentially recorded in palatial texts.

5.3 Cereal and pulse crops of later Bronze Age Greece: textual evidence

The consensus is that the Linear B script includes two or three ideograms representing cereals and none for pulses. Ventris and Chadwick (1973, 130) identified ideograms *120 and *121, measured in dry units and the major components of "ration" records, as representing staple cereals, a view consistent with their association (*120 at Mycenae and Thebes; *121 at Knossos) with *si-to*, which as Homeric and Classical Greek *sitos* signified "corn", "grain", or "food" (prepared from grain) (Palmer 2008, 621, 629-632). A third ideogram, *129, also measured in dry units and associated (once at Pylos) with *me-re-u-ro*, represents "flour" or conceivably a third cereal suited to producing flour (Ventris and Chadwick 1973, 458). Some Linear B ideograms are evidently modelled on precursors in the earlier Minoan scripts: Palmer (2008, 624-625) has pointed to similarities of form and use between *120 in Linear B and AB 120 in Linear A and, more ambiguously, between the latter and Hieroglyphic *153; *121 in Linear B exhibits weaker similarities of form and use with A 303 in Linear A and has no evident Hieroglyphic precursor (Palmer 2008, 626-627); and *129 in Linear B might conceivably be modelled on AB 65 in Linear A (Palmer 2008, 626-627).

Ventris and Chadwick (1973) identified Linear B *120 as wheat and *121 as barley, the latter already suggested by Evans (1935, 625-626), while acknowledging that their identifications might be reversed as subsequently proposed by Palmer (1992; 2008). Evans' original identification of *121 was based on (rather vague) similarities in form to other Bronze Age representations that he attributed to barley (Evans 1935, 625-628), while Ventris and Chadwick (1973, 439) suggested that *121 exhibits a "beard" (awns) characteristic of barley. Recent Greek farmers frequently cited the awns of barley, but not *free-threshing* wheat, as posing problems during harvest and consumption of the straw by livestock, but most einkorn, emmer and macaroni wheat varieties (Percival 1921, 104-105, 209), and also more Mediterranean than temperate varieties of bread wheat (Börner et al 2005), are bearded. Perhaps more significantly, Linear B *120 and its suggested Linear A (AB 120) and Hieroglyphic (H *153) precursors bear some resemblance to an upright cereal ear (cf. Palmer 2008, 624 fig. 1), whereas Linear B *121 and its possible Linear A precursor (A303) resemble an ear leaning to the side (cf. Palmer 2008, 626 fig. 2). Although some glume wheats lean more than free-threshing wheat when ripe, a nodding ear is particularly characteristic of barley, as recalled by the Cretan mnemonic advising *krithári géro thérize, sitári pallikári* or "harvest barley as an old man, wheat as an upstanding young man" (Halstead 2014, 76). Linear B *120 and *121 should thus represent wheat and barley (Halstead 1995), respectively, if intended to convey visual cues to their identity, although clearly recognizable images are more typical of ideograms first designed for Linear B, as Palmer (2008, 638) argues for *121, than for ideograms with a long history of prior use (Weilhartner 2014, 298-299). Previously the Pylos Linear B text An 128 was thought to support this interpretation of the two ideograms, because a ration of *120 on its obverse face was apparently substituted by roughly double the quantity of *121 on its reverse face; *120 would thus be more valuable and represent wheat, while *121 represented barley, but there is no indication that the two entries should be read as equivalents (Ventris and Chadwick 1973, 412; Palmer 1992, 487).

Palmer's case for reversing the identifications of Linear B *120 and *121, as (hulled six-row) barley and (emmer) wheat, respectively, is largely based on three contrasts in the ideograms' contextual associations.

(1) *120, but not *121, is mentioned in Knossos harvest (or bulk storage – Killen 1995) records. Palmer notes that the proposed late May-early June destruction of the Knossos palace, and thus preservation by burning of most of its surviving Linear B tablets, coincides with the cereal harvest on Crete. Accordingly, *121 harvest records might be lacking

because the palace had taken delivery of earlier-ripening barley, but not later-ripening wheat (Palmer 1992, 485). Although some traditional southern Greek six-row barley varieties, sown in a mixed crop with free-threshing wheat, ripened late together with the latter (Halstead 2014, 76), barley usually ripened before wheat. On the other hand, it is unknown whether*120 and *121 represent some type of wheat and barley rather than, say, free-threshing and glume wheat; indeed the latter possibility is compatible with Palmer's appeal to the timing of the palace's destruction, because harvest is less urgent for ripe glume than ripe free-threshing wheats (Halstead 2014, 72). Alternatively, if *120 represents glume wheat or hulled barley (or, indeed, both) in the glume/hull and *121 the de-husked grain, then the absence of harvest/storage records for the latter would be self-explanatory. In any case, the timing of the Knossos palace's destruction does not resolve the identity of the Linear B cereal ideograms. Moreover, the lack of recognized ideograms for pulses, despite their representation among charred grain in palatial complexes, makes clear that Linear B provides a selective record of the grains consumed. Accordingly, *121 harvest records may be lacking because the palace acquired this crop (like pulses) by a mechanism that left no "paper-trail" (e.g. Bennet and Halstead 2014; also Palmer 1992, 484-485), whereas the palace did exercise text-aided administrative oversight over the harvest/storage (and probably also cultivation – Killen 1998; Halstead 1999) of *120.

(2) Seed (*pe-mo* or *pe-ma*) of *120, but not *121, is used as a measure of land area. Palmer argues that land would be measured in the less demanding cereal that could be grown on a wider range of soils, implying that *120 represents barley rather than wheat (Palmer 1992, 481, 483, 486-7; 2008, 623). On the other hand, this argument is equally compatible with *120 and *121 representing glume and free-threshing wheat, respectively (with einkorn especially tolerant of poor growing conditions) or indeed hulled and dehusked grain, respectively, since grain would be sown without dehusking (Halstead 2014, 138-139). Conversely, the palaces may well have been interested only in high-quality arable land, so seed-corn measures may have assumed favourable conditions, as apparently did recent Greek farmers' use of "days-of-ploughing" to measure arable land (Halstead 2014, 37-38). Moreover, if the restriction of harvest records to *120 does reflect selective palatial involvement in cereal production, then seed-corn measurements of arable land would surely be expressed in the selected cereal – whatever its identity.

(3) *120 is issued as rations to dependent workers, whereas *121 is given to religious personnel and deities. Palmer argues that dependent workers would receive the cereal of lower value, which should be barley rather than wheat (Palmer 1992, 485-486). In favour of this argument, the various cereals of the Mediterranean have since Classical antiquity enjoyed unequal status, with wheat, especially free-threshing rather than glume wheat, normally more highly regarded than barley (e.g. Garnsey 1999, 119-121; Halstead 2014, 164-166). On the other hand, we again do not know that *120 and *121 represent some type of wheat and barley (or *vice versa*), rather than two types of wheat or glume wheat/hulled barley at different stages of processing, and anyway the relative cultural value of the different cereal crops in the later Bronze Age should, for reasons set out below, be investigated rather than assumed.

In addition, Killen (2004, 165-166) discusses possible independent support for Palmer's view from Knossos text G 820, apparently listing rations for groups of women. Such groups elsewhere in the Linear B corpus receive rations of *120, but in this case the only possible indication of what is to be issued is provided not by an ideogram but by the word *ki-ri-ta*, plausibly read as *kritha* or barley. The text is incomplete and somewhat enigmatic, however, and (if *ki-ri-ta* is correctly interpreted as barley) the commodity to be issued as rations might have been "spelled out", rather than indicated by an ideogram, for clarity precisely because it deviated from normal practice rather than because *ki-ri-ta* and *120 were alternative representations of the same type of grain.

In sum, Palmer's arguments for identifying Linear B *120 and *121 as barley and wheat, respectively, are unconvincing, but the conventional (reverse) identifications are also insecure and, on presently available textual evidence (Killen 2004), these two ideograms cannot definitively be identified to grain species or processing stage. Moreover, since Linear B records deal only selectively with the range of grain crops attested by charred remains, even a significant increase in the quality and quantity of archaeobotanical evidence may not provide a solution. On the other hand, the Linear B record is selective regarding not only which grain crops were grown and consumed, but also the contextual associations of disbursements in the commodities that were represented by the grain ideograms (Killen 2004, 168):

1. *120 is normally, if not always, issued as rations to groups of women workers and their children;
2. *121 is issued as rations to male workers (who occasionally receive *120) and as allowances to male and female participants in religious festivals, and is also the main cereal in "menus" for state-sponsored sacrificial banquets and in offerings to divinities;
3. *129 is recorded only in religious contexts (sacrificial banquet "menus" and offerings to divinities) and thus tends to co-occur with *121.

Even if the identity of the crop species and/or processing stages represented by Linear B *120, *121 and *129 remains uncertain, the selective use of different grain types in the palatial societies of southern Greece is arguably of considerable interest and significance, for reasons outlined in the following section.

5.4 Status and use of grain crops in the recent Mediterranean

A pervasive feature of traditional rural Mediterranean food cultures was a hierarchy of staple grains: high-status food grains (e.g. free-threshing wheat, chickpea) consumed regularly by the relatively affluent and on special occasions by poorer neighbours; low-status food grains (e.g. emmer, barley, broad bean) consumed regularly by the rural poor; and fodder grains (e.g. oat, bitter vetch) normally reserved for livestock (Halstead 2014, 291). Processing for consumption reinforces this ranking: grain for human food, but not animal fodder, was thoroughly cleaned of chaff and weed seeds and the protective coverings were removed from hulled barley and glume wheat grains (Halstead 2014, 132, 134, 139); and cereal grain for food on special occasions might be differentiated from its daily counterpart by stripping off (whole grains, groats) or sifting out (flour) much of the bran (Halstead 2014, 163-165).

This hierarchy can be understood in both practical and cultural terms (*sensu* Sahlins 1976). On the one hand, high-ranking cereals, such as free-threshing wheats, require better growing conditions than low-ranking barley, rye or oats; for some pulses, food and fodder varieties are differentiated by the thickness and colour of the testa, with food varieties more palatable but less protected against pests and so harder to grow and store; thoroughly cleaned grain avoids the risks to human health of consuming toxic weed seeds; and "pearled" grains stripped of bran are costlier (additional processing labour and lower volume of grain available for consumption) than whole grains and may reduce flatulence. On the other hand, free-threshing bread wheat is preferred to other cereals because it is suitable for making leavened loaves, a hallmark of urban sophistication since Classical antiquity in the central and west Mediterranean (Garnsey 1999, 119-122; and perhaps since the 4th mill BCE in the Near East – Sherratt 2006, cited in Goulder 2010, 359), in contrast to the rustic connotations of the flat-breads or gruels typically made from "lesser" cereals. The practical and the cultural are also intertwined. Thus, leavened bread perhaps initially acquired its urban connotations as a more practical solution, than flat-bread of short shelf-life (Majzoobi et al 2011) or logistically difficult gruel, to the demands of efficient mass provisioning (cf. Goulder 2010). Similarly, the widespread cultural preference for light-coloured cereal products perhaps originally reflected the higher value attributed to (especially free-threshing) wheat over darker barley or rye, and to pearled over whole grains; it also, however, led some recent Cretan farmers to use the whitish flour of two-row hulled barley as a surrogate for wheat in loaves baked for church offerings or domestic consumption at major festivals, while some in Asturias adopted unnecessarily laborious and damaging methods of threshing spelt ears to achieve whiter flour (Halstead 2014, 25-26, 165). Food cultures, however, also introduce regional and local variability into relative values of grains. For example, grass peas (of a large, light-coloured variety) and lupins may be encountered in Italian delicatessens, but were widely regarded in Greece a few decades ago as primarily fodder crops, while green barley rather than the more usual ripe wheat was selected for making groats on southern Aegean Kythera (Halstead 2014, 138). Likewise, while glume wheats latterly were mostly relegated to fodder, they survived in a few hilly areas as the basis of emblematic local foods: spelt/emmer loaves in Asturias, einkorn soup in Haute Provence, emmer "farrotto" in Tuscany, and einkorn/emmer bulgur in northern Turkey (Ertuğ 2004).

The hierarchy has important consequences, again both practical and cultural. On the one hand, the types of grain product a household consumes, especially when subject to wider scrutiny as in festival offerings or hospitality, are a hallmark of social and economic standing with practical implications for hiring workers, selling produce and securing marriage partners (Halstead 2012a; 2014, 165-166). On the other hand, while social standing encourages consumption of high-ranked products, scarcity periodically forces consumers down the scale, from "urban" to "rustic" food and, for the poor or in famine years, from "rustic" food to fodder (e.g. Halstead 1990), with stores of low-status food and fodder providing a vital safety net once available surpluses of preferred grains are exhausted. The interdependence of practical and cultural parameters is critical, with the stigma of eating low-status grains helping to reserve famine foods for emergencies. The ranking of grain species and products was thus of considerable sociological and economic significance in the recent past and likewise in Classical antiquity, highlighting the importance of knowing whether similar cultural rules prevailed in Bronze Age or even Neolithic societies.

5.5 Status and use of grain crops in the ancient Mediterranean – archaeobotanical evidence

Archaeobotanical evaluation of the status and use of staple grains has focused primarily on distinction of food from fodder. In the recent past, grain for fodder was usually cleaned less thoroughly (without fine-sieving or hand-picking) than that for food (Halstead 2014, 155-156). Straw and grain tended to be fed to different animals, however, so food and fodder crops alike were threshed and winnowed/coarse-sieved, and placed into long-term storage in much the same state, often in the same facilities – consistent with the tendency for farmers to divert to livestock whatever stored grain was surplus to requirements or most at risk of spoiling (Jones 1998; Halstead 2014, 291). Neither degree of cleaning nor context of storage, therefore, reliably distinguishes food from fodder grain (Jones 1998). Charred animal dung and products of food preparation (groats, flour, "split peas") potentially offer more direct evidence for the final use of grains, but such finds are as yet relatively scarce and their distinctive formation processes may remove all trace of grains from the former (Valamoti and Charles 2005) and prevent identification in the latter (Sarpaki 2001, 33-34). Moreover, in the recent past, fodder as well as food grains might be reduced to groats or flour, depending on the type of animal to be fed (e.g. Halstead and Jones, 1989, 46-47; Halstead 2014, 139), although it seems unlikely that such labour-intensive and unnecessary treatments as de-husking glume wheat/hulled barley or parboiling grains before making groats were applied to fodder in the recent or distant past (Valamoti 2002, 20-21). In a similar vein, the progressive displacement of glume by free-threshing wheats (Halstead 2012b, 25-26; Heinrich 2017) and conversely of naked by hulled barley (Lister and Jones 2013), from the 3rd mill BCE in the Near East, 2nd-1st mill BCE in the Aegean and 1st mill BCE-1st mill AD in temperate Europe, might reflect the widespread emergence of free-threshing wheat and hulled barley as preferred food and fodder grains, respectively.

One further archaeobotanical avenue may be considered – stable carbon and nitrogen isotope analysis of crop grains to explore their growing conditions and thus the level of investment in their production. Experimental work in the Mediterranean has shown that the ratio of the heavier (^{13}C) to lighter (^{12}C) stable isotope of carbon (expressed as $\delta^{13}C$ values) in wheat and barley grains reflects water availability during growth, especially during its later stages (Farquhar et al 1989; Araus et al 1997; Wallace et al 2013). Barley $\delta^{13}C$ values tend to be 1-2‰ lower ("wetter") than those of wheat grown under the same conditions, perhaps because barley completes photosynthesis and ripens earlier (Anyia et al 2007; Flohr et al 2011; Wallace et al 2013; cf. Styring et al 2017). Pulse $\delta^{13}C$ values also reflect water status during growth but appear more sensitive to watering level than wheat, such that they appear "wetter" in stable carbon isotope terms than similarly well-watered wheat but "drier" than wheat when both are grown under suboptimal watering conditions (Wallace et al 2013). For nitrogen, the ratio of ^{15}N to ^{14}N (expressed as $\delta^{15}N$ values) in cereal grains reflects soil nitrogen composition, influenced most dramatically in arable fields by manuring rate (Bol et al 2005; Fraser et al 2011). In pulses, which can fix atmospheric nitrogen, the manuring effect is less marked and only emerges under very intensive manuring (Fraser et al 2011; Treasure et al 2016). Measurement of stable C and N isotope values in cereals and pulses across a number of Neolithic and Bronze Age sites in northern and southern Greece (Vaiglova et al 2014; 2020; 2021; Nitsch et al 2017; 2019) has so far yielded the following observations relevant to the question of early staple grain "status":

1. At individual Neolithic and Bronze Age sites, different cereal crops (wheats and/or barleys) may have distinct $\delta^{13}C$ and/or $\delta^{15}N$ values, reflecting differential growing conditions, but these contrasts are inconsistent between sites, apparently reflecting local ecological and cultural settings.
2. At all Neolithic sites so far investigated, and at Bronze Age sites in northern Greece, pulse growing conditions overlap with those of cereals, suggesting that they were grown together or in rotation; by contrast, at Final Palatial Knossos (storeroom P of the Unexplored Mansion), cereals (six-row hulled barley and emmer) were better watered but less manured than pulses, suggesting that cereals were grown separately from pulses and under less intensive conditions; data for later Bronze Age free-threshing wheat are available only for Archontiko and Toumba Thessalonikis in Macedonia, where this crop is not better treated than glume wheats or hulled barley.
3. At Final Palatial Knossos, emmer and six-row hulled barley are grown under somewhat contrasting conditions (emmer better watered and mostly less manured), but probably on high-quality (certainly well-watered) land. Unexplored Mansion storeroom P has been characterized as a larder rather than granary, because the crops had been thoroughly cleaned of weed seeds (Jones 1987), and their containers of modest "portable" size were perhaps re-filled periodically from palace stores (Christakis 1999, 12-13) or from the spacious storage area of the elite Little Palace (Hatzaki 2005, plans 2-3; Christakis 2008, 127), to which the Mansion was connected. Isotopically, the storeroom P barley and emmer appear to be derived from one and two distinct plots, respectively, and so arguably from a Little Palace estate rather than pooled/redistributed palatial stores (cf. Whitelaw 2019, 105, 108).

Although the grain in the Unexplored Mansion was probably not subject to palatial monitoring in writing, its growing conditions provide no support for a clear contrast in cultural value between emmer and six-row hulled barley at Final Palatial Knossos. There is also strong isotopic (and weed ecological) evidence that these cereals were grown under similar, mostly low-input, conditions in an earlier, indisputably institutional context in Anatolia: a massive early Hittite state granary at 16th c BC Hattusha in which tons of grain were charred in a major fire (Diffey et al 2020). As in the ethnographic evidence reviewed above, the Hittite state apparently regarded both hulled barley and emmer as relatively low-status/stress-tolerant "hulled" cereals. An Aegean palatial contrast between emmer and hulled barley, therefore, comparable to the Classical distinction between free-threshing wheat and hulled barley, seems implausible.

5.6 Conclusions

Charred plant remains from the non-palatial north and palatial south alike of later Bronze Age Greece represent diverse cereal and pulse crops, processed for consumption in various ways. For the south, this diversity highlights the selectivity of written records, which list only cereals, and also the breadth of candidates for the cereal types represented by Linear B ideograms *120, *121 and perhaps *129 (and likewise their suspected Linear A and Hieroglyphic precursors). Most discussion hitherto of the latter question has accepted that *120 and *121 represent wheat (probably emmer) and barley or *vice versa*, the latter view based on the ideograms' contrasting contextual associations and the assumed earlier ripening, less demanding growth requirements, and (on the basis of Classical Greek sources) lower cultural value of barley than emmer. These assumptions are questionable, however, especially given uncertainty that the recorded cereal categories are indeed hulled barley and emmer. The relative value of the grain crops attested by charred remains can also be explored in archaeobotanical evidence for the care invested in their cultivation and preparation for consumption. While evidence for the latter is sparse and ambivalent, stable isotope analysis of growing conditions does not support extrapolation to later Bronze Age Greece of the low cultural value assigned to hulled barley in Classical times. In this light, it might be argued that Linear B *121, distributed to higher-status consumers than was *120, represents free-threshing wheat, but available stable isotope data, albeit from non-palatial northern Greece, does not support a higher value for this cereal than for glume wheats or hulled barley, while the "nodding" form of the *121 ideogram resembles free-threshing wheat least of all the alternatives. Available evidence is thus insufficient to determine which cereal categories were represented by Linear B *120, *121 and *129 or their precursors, and indeed whether they represent distinct taxa rather than (hulled) cereals processed to differing degrees.

Nonetheless, the contrasting contextual associations of the Linear B cereal ideograms confirm that different cereal commodities had contrasting cultural meanings in the later Bronze Age Aegean, while stable isotope data suggest that this was also the case for cereals and pulses throughout the Bronze Age and preceding Neolithic. These cultural meanings were locally variable, however, judging by the isotopic evidence for which crops were "favoured" with intensive husbandry. This contrasts with apparently more widespread uniformity in crop values in Classical antiquity, which is perhaps at least partly a product of growing international trade in grain. For the Neolithic and Bronze Age Aegean, the apparently varied meanings ascribed to different grain species (and, doubtless, different culinary preparations) most probably played significant if currently imperceptible roles both (as in the recent past) in negotiating the identities of consumers and in navigating between periods of plenty and scarcity.

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Chapter 6

Early Chalcolithic plant economy at Aktopraklık Höyük in northwest Anatolia: preliminary findings

Ceren Kabukcu, Eleni Asouti, Emma Percival, Ellen Grice, Necmi Karul

Abstract

This chapter presents preliminary archaeobotanical evidence from the Early Chalcolithic occupation at the site of Aktopraklık Höyük in northwest Anatolia, near the south Marmara coast. Samples collected in 2016-17 and processed during the 2017-2019 field seasons, using a rigorous recovery strategy, have yielded a rich and diverse archaeobotanical assemblage, containing ubiquitous and abundant crop remains as well as charred fruit, seeds and nutshell from indoor floor deposits and outdoor courtyard and communal areas. Our preliminary results also indicate spatial variation between indoor and outdoor areas with regard to crop processing and food preparation and consumption activities.

Keywords: *Chalcolithic, archaeobotany, Anatolia*

6.1 Introduction

6.1.1 The study area

Aktopraklık Höyük is located in northwest Anatolia, approximately 25 km from the Marmara Sea on the eastern terraces of Lake Ulubat. Ongoing excavations at the site since 2002 have uncovered three distinct areas of occupation (A-C) spanning the Late Neolithic and Early Chalcolithic (ca 6400-5600 cal BC) (Karul 2017; Karul and Avcı 2011). While sampling for archaeobotanical remains had been carried out from the initial stages of excavation, reporting on this material, including samples from both Neolithic and Chalcolithic deposits, has been limited. The study of the anthracological remains (Schroedter and Nelle 2015) indicated the presence of mixed deciduous woodland in close proximity to the site including hazel, plums/cherries, oak, etc. The samples available for the present study were recovered during the 2015-2017 excavation seasons, which targeted Early Chalcolithic occupation layers dug in Area B (dated to ca 5900-5750 cal BC) including a series of buildings arranged in a semi-circular plan surrounded by a large ditch/channel structure (see Fig. 6.1). The buildings of Area B encircle a large, external/communal area at the centre of the settlement. Ovens and hearths are found inside buildings, with larger ovens also occurring in external spaces.

While there is an abundance of published archaeobotanical studies from other regions of Anatolia (e.g. central and southeast Anatolia; see Bogaard et al 2017, 2021; Kabukcu

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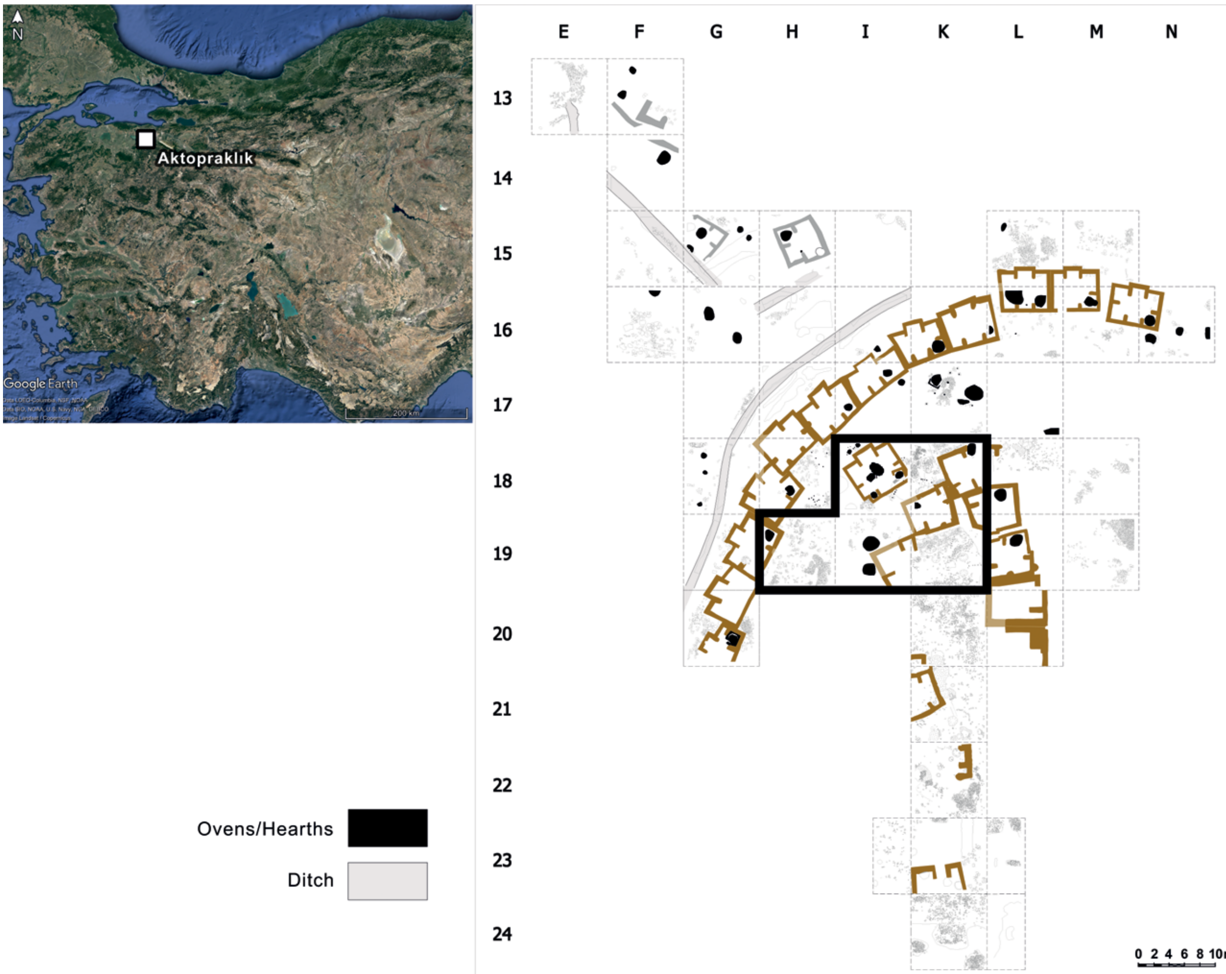

Fig. 6.1 Location of the site and map of Area B (highlighted in thick black line are the excavation squares sampled for archaeobotanical remains in 2016-17).

et al 2021, and references therein) to date published reports on crop economies and plant use from Neolithic and Chalcolithic sites in western and northern Anatolia have been limited. In this paper we present preliminary findings on the Aktopraklık materials and outline future directions of research based on these early results.

6.1.2 Previous archaeobotanical and archaeobiological research at Aktopraklık

Previous analyses on wood charcoal remains and carpological finds from Aktopraklık reported in Schroedter and Nelle (2015) have suggested the exploitation of a diverse woodland catchment in the environs of the site. The examined samples, spanning all phases of occupation from the Late Neolithic to the Chalcolithic, indicate the existence of a diverse vegetation cover including *Pistacia*, *Rhamnus*/*Phillyrea*, *Prunus* spp., Maloideae, *Fraxinus*, *Pinus*, Cupressaceae, etc. The dominant fuel wood species were deciduous and evergreen *Quercus* and *Carpinus*, indicating the local presence of mixed oak-hornbeam woodland. The presence of *Corylus* wood and nutshell in Neolithic and Chalcolithic samples points to the early use of this taxon as a source of gathered food in northwest Anatolia.

The preliminary results of zooarchaeological analyses at Aktopraklık indicate the importance of domesticated animals in the subsistence economy, notably caprines (sheep and goat) and cattle alongside a reliance on hunted mammals such as fallow deer (Budd et al 2013, 2018). $\delta^{13}C$ and $\delta^{15}N$ isotopic determinations on human remains from the site had previously suggested a potentially greater reliance on animal products as sources of dietary protein compared to crops (Budd et al 2013, 2018). However, the authors noted that the consumption of crops grown in manured fields could have also contributed to the isotopic signatures of human remains. At that time, evidence for crop use such as cereal and pulse seeds, chaff and wild/weedy taxa had not been recovered (Schroedter and

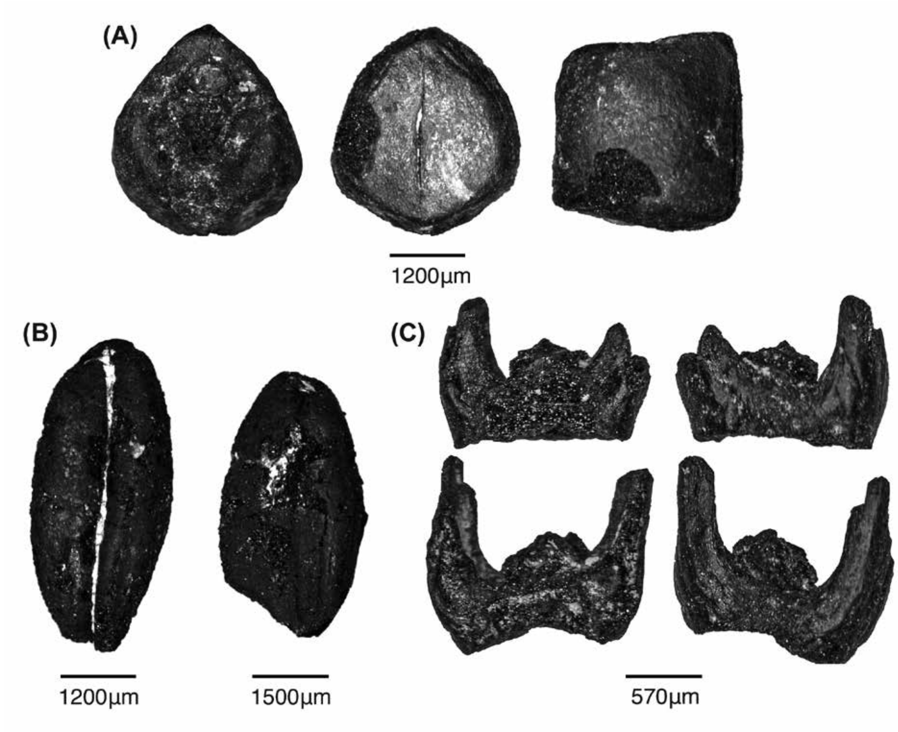

Fig. 6.2 Selected archaeobotanical finds from Aktopraklık. a *Lathyrus*; b *T. monococcum* grain; c *T. monococcum* spikelet forks.

Nelle 2015). This probably reflects the sampling strategy adopted by Schroedter and Nelle (2015) which focused primarily on non-domestic, external areas and outdoor pits, avoiding building spaces and features such as hearths and ovens, in order to maximise the utility of the sampled deposits for palaeoenvironmental reconstruction (see also Kabukcu and Chabal 2021). One of the key objectives of the current archaeobotanical project at Aktopraklık has been to increase the scale, intensity and spatial coverage of archaeobotanical sampling, by systematically collecting sediment samples ≥40 *l* from a broad range of archaeological contexts and features. Samples are routinely processed by machine-assisted flotation using a 3-tank high-capacity recycling water system. The light flot fractions (containing charred plant remains and light shells) were captured with a chiffon mesh, labelled and hung to dry slowly in the shade. The heavy residue fractions (containing mostly lithic and bone debris, pottery fragments, microfauna and very small artefacts) were retained in a 500 μm nylon mesh that was securely pegged to the walls of the flot tank. Once dried, flot fractions were passed through a stack of geological test sieves (meshes 4mm, 2mm, 1mm, 500μm and 250μm). The >4->1mm fractions were sorted in their entirety under a Leica S8APO stereozoom microscope (magnifications x10-x80). The remaining fractions were subsampled with a riffle box. The application of this processing protocol resulted in a significant improvement of charred plant recovery rates and the overall density of archaeobotanical remains (particularly for fractions <500μm). Furthermore, the introduction of a highly efficient sediment washing system has greatly improved recovery rates from the marl-rich clayey soils characteristic of the site.

6.2 Preliminary archaeobotanical results

6.2.1 Archaeobotanical finds

To date >2000 litres of sediment (corresponding to ~50 flotation samples) have been processed deriving from domestic floor contexts from 2 excavated buildings and outdoor spaces dug in the central part of Area B (see Fig. 6.1). While full sorting and quantification of the charred wood and non-wood macrofossils are ongoing, the first results of our analysis confirm the ubiquitous presence of a diverse crop suite including glume wheats (*Triticum monococcum*, *T. turgidum* subsp. *dicoccum*, *T. timopheevi* (“new” glume wheat/NGW) (Figs 6.2-6.3), free-threshing wheat (*T. aestivum / durum*), and naked and hulled barley (*Hordeum vulgare* var. *nudum*, *H. vulgare*). Verified pulse crops so far include *Lens*, *Vicia ervilia* and *Lathyrus sativus*. In addition, nut and fruit remains such as *Pistacia* and *Ficus carica* are ubiquitous (Fig. 6.4). Cereal chaff remains are also very abundant and ubiquitous, including hundreds of charred awn fragments, which further testify to the effectiveness and precision of the new sampling and flotation recovery methods adopted at Aktopraklık.

A preliminary comparison of crop and wild fruit and nut presence between Aktopraklık and other Neolithic and Chalcolithic sites in Anatolia (Table 6.1) demonstrates the unique nature of the Aktopraklık crop

Fig. 6.3 *T. timopheevi* ("New" glume wheat/NGW) spikelet fork from Aktopraklık.

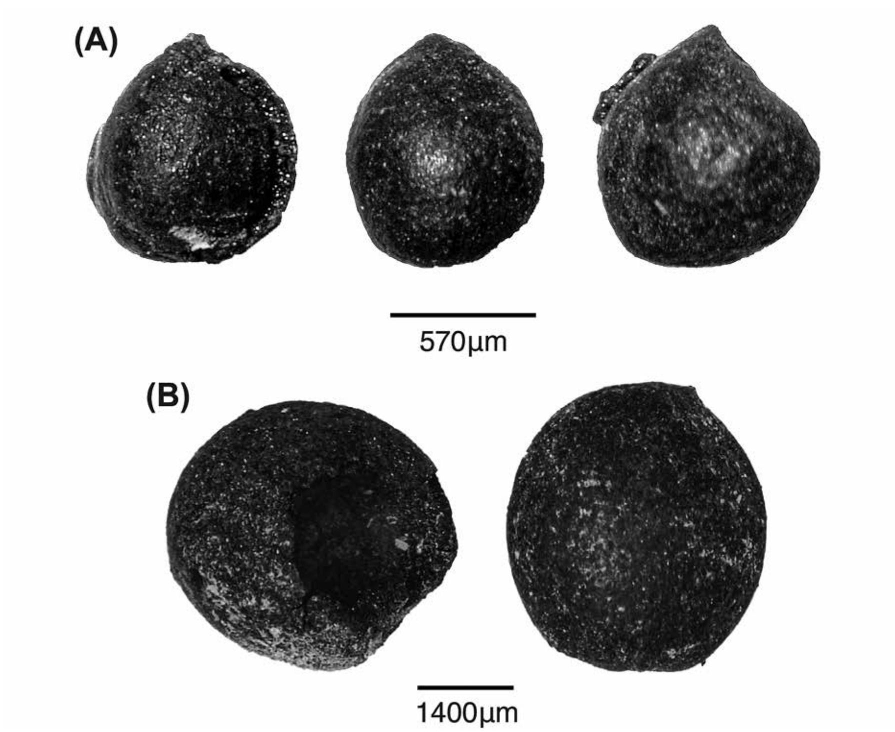

Fig. 6.4 Selected archaeobotanical finds from Aktopraklık. a *Ficus carica*; b *Pistacia.*

assemblage. Notably, NGW has thus far not been reported from other sites in northwest Anatolia, such as Ilıpınar and Barcın, dated to the Neolithic and Chalcolithic periods (Cappers 2008; Balcı et al 2019). NGW has been previously reported from Neolithic layers excavated at Yenikapı (Ulaş 2021; Ulaş and Fiorentino 2021). NGW is an important component of crop assemblages reported from central Anatolian Neolithic and Chalcolithic sites (e.g. the Çatalhöyük East and West mounds: Bogaard et al 2017, 2021; Stroud 2016). We should note here that NGW could have also existed at other Neolithic sites such as Höyücek and Hacılar the archaeobotanical studies of which predate its identification) and from Yumuktepe on the southern Anatolian coast (Fiorentino et al 2014).

Furthermore, while *Pistacia* is found at Aktopraklık (both as wood charcoal and nutshell), this taxon is absent from Ilıpınar and Barcın. This regional disparity in the use of *Pistacia* also stands in contrast to the pattern observed in Neolithic and Chalcolithic occupations in central and southwest Anatolia (Table 6.1). In fact, *Pistacia* and almond are some of the most ubiquitous wild fruit/nut taxa used across Anatolia, a tradition which continues from earlier periods (Ergün et al 2018). The presence of both NGW and *Pistacia* at Aktopraklık (if not attributed to preservation and recovery factors) may thus point to a greater affinity and/or continuity with regard to plant use and culinary choices with occupations further afield in central and southern Anatolia.

Period	Region	Site	Einkorn	Emmer	New glume wheat	Free-threshing wheat	Hulled barley	Naked barley
N	NW	Yenikapı	x	x	x	x	x	x
N	NW	Pendik Höyük		x(?)			x	
N/C	NW	Ilıpınar	x	x		x	x	x
N/C	NW	Barçın Höyük	x	x		x	x	
N/C	NW	Aktopraklık	x	x	x	x	x	x
N	C	Çatalhöyük East	x	x	x	x	x	x
C	C	Çatalhöyük West	x	x	x	x	x	x
N	C	Erbaba	x	x		x	x	x
N	SW	Höyücek		x		x	x	x
N	SW	Hacılar	x	x		x	x	
N/C	S-Med	Yumuktepe	x	x	x	x	x	x

Site	Lentil	Bitter vetch	Grass pea	Chick pea	Pea	Flax	Terebinth/Pistacia	Almond	Fig	Hazel
Yenikapı	x	x	x	x	x	x			x	
Pendik Höyük			x		x	x				
Ilıpınar	x	x	x	x	x	x			x	x
Barçın Höyük	x	x		x	x	x				x
Aktopraklık	x	x	x			x	x		x	x
Çatalhöyük East	x	x	x	x	x	x	x	x	x	
Çatalhöyük West	x	x	x	x	x		x	x	x	
Erbaba	x	x	x		x					
Höyücek	x	x	?	x	x		x			
Hacılar	x	x	x	x	x		x	x		
Yumuktepe	x	x		x	x	x	x	x	x	

Table 6.1 Presence of main crop and wild fruit/nut taxa across selected Neolithic and Chalcolithic sites in Anatolia. Period: N= Neolithic, C=Chalcolithic. Region: NW=northwest, C=central, SW=southwest, S-Med= south, Mediterranean coast. Yenikapı and Pendik: Ulaş 2021; Ilıpınar: Cappers 2008; Barçın höyük: Balcı et al 2018 ; Çatalhöyük East: Bogaard et al 2017; Çatalhöyük West: Stroud 2016; Erbaba: van Zeist and Buitenhuis 1983; Höyücek: Martinoli and Nesbitt 2003; Hacılar: Helbaek 1970; Yumuktepe: Fiorentino et al 2014.

All three sampled sites located in the Marmara region (Aktopraklık, Barcın, Ilıpınar) have provided early evidence of the use of *Corylus* (hazel) starting from the late Neolithic and continuing into the early Chalcolithic. This probably reflects an environmental gradient, as hazel is a taxon characteristic of more humid temperate environments. Another interesting commonality of crop use with Barcın and Ilıpınar is the presence of abundant remains of flax (*Linum usitatissimum*) at all three sites (Cappers 2008; Balcı et al 2019). Flax is ubiquitous at Aktopraklik; it is hoped that further work will provide greater insights into the antiquity of its use at the site and its potential uses.

A significant divergence between the northwest and central Anatolian Neolithic and Chalcolithic occupations is the absence of dung remains from Aktopraklık, Barcın and Ilıpınar. The reliance on this fuel type is very well documented in central Anatolian sites (Bogaard et al 2017, 2021; Stroud 2016; Ergün et al 2018). Thus far we have not found charred or mineralised dung remains at Aktopraklık (despite the confirmed presence of caprines from its earliest phases). Future archaeobotanical analyses, coupled with planned micromorphology work, will clarify whether dung was among the fuel sources exploited by the site inhabitants.

6.2.2 Emerging evidence of crop use and processing activities

While full sorting, identification and quantification of the Aktopraklık archaeobotanical samples are ongoing, some preliminary observations on the nature of crop use and food preparation activities at the site are feasible. As expected, the composition of the samples originating from domestic floor deposits indicates final stages of crop cleaning prior to consumption. These samples contain overall fewer botanical remains compared to outdoor contexts including small quantities of glume wheat chaff with low inputs of wild/weedy taxa (e.g. *Galium*, Brassicaceae and small-seeded Fabaceae). Some also contain charred plant aggregates, of similar structure and morphology as previously described by Valamoti (2002) and Valamoti et al (2019). Plant aggregates appear either more homogenous (likely involving finer grinding of seeds) or they contain a mixture of fine to medium particle sizes (Fig. 6.5).

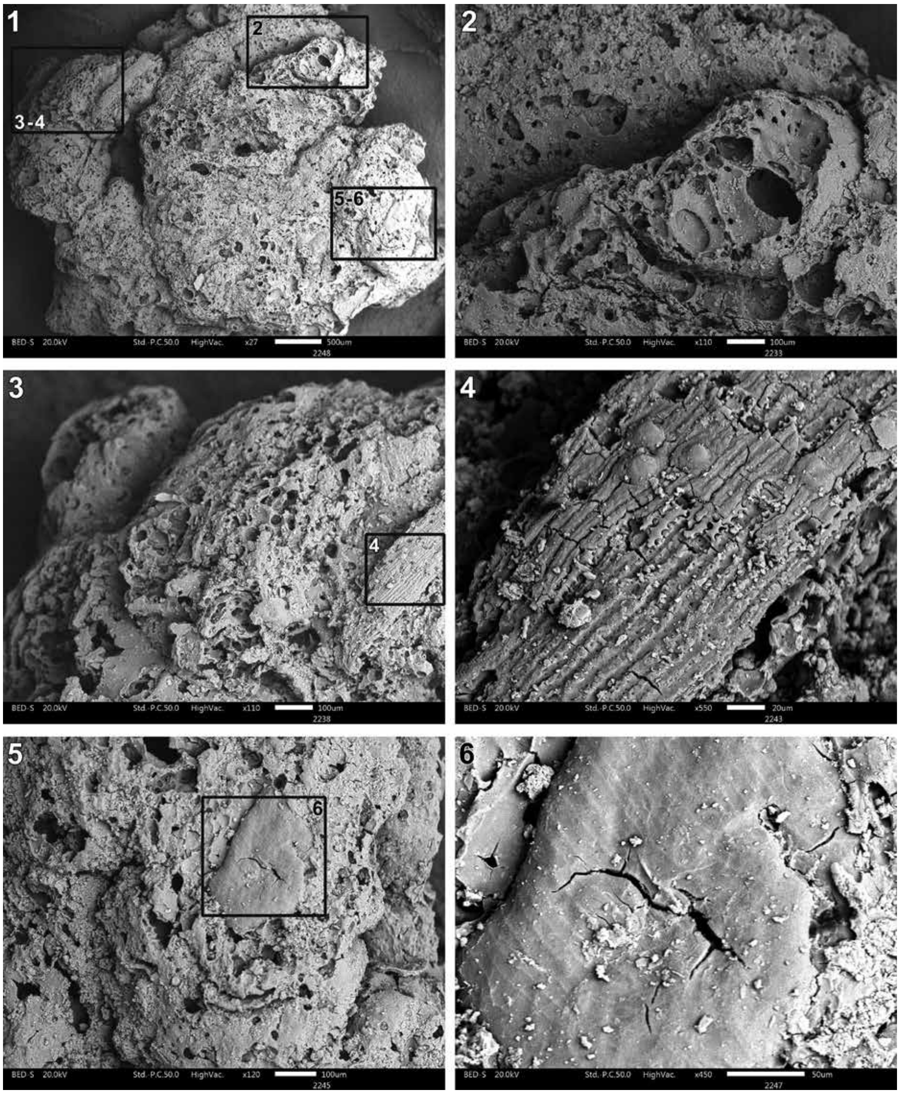

Fig. 6.5 SEM micrographs of charred plant aggregate fragment from Aktopraklık (square from 18I). 1 Overview of the fragment; 2 Close-up showing variable porosity in the matrix; 3-4 Close-up showing cereal husk inclusion and multi-cells; 5-6 Close-up showing transverse cell layers.

By contrast, the samples originating from outdoor areas have yielded high concentrations of glume wheat chaff, free-threshing wheat and barley rachises, and high concentrations of cereal awn fragments as well as several wild/weedy taxa. Thus far, the charred aggregates recovered from outdoor contexts are distinctly different from those found in domestic contexts. They are characterised by large size inclusions of cereal grain and may represent cooked/boiled cracked/coarse ground grain food debris. Additionally, some charred aggregates from these samples also display distortion associated with high temperature burning and/or high moisture content impacting the state of preservation and their analytical potential (Valamoti et al 2019, 2021).

6.3 Future directions of archaeobotanical research at Aktopraklık

The picture emerging from the first systematic archaeobotanical investigations conducted at Aktopraklık confirm that cereal, pulse and oil crop cultivation formed an important component of the site economy and subsistence practices during the Early Chalcolithic period. Although no samples are as yet available for analysis from Neolithic strata at the site, there is no doubt that agricultural production held a prominent position in Neolithic subsistence production as well. Our field sampling programme and improved archaeobotanical recovery methods also demonstrate the importance of retrieving sufficiently large sediment samples processed by large-scale, machine-assisted flotation for obtaining a representative picture of the diversity and spatial variation of prehistoric plant use. With regard to spatial variation, the first results of our work suggest that crop processing was a communal activity, indicated by the abundant finds of chaff and awn remains in outdoor areas. By contrast, the limited range of fully studied domestic indoor contexts appear to contain the final stages of crop cleaning prior to cooking. Indoor contexts studied from 19H contain a greater quantity of glume bases and spikelet

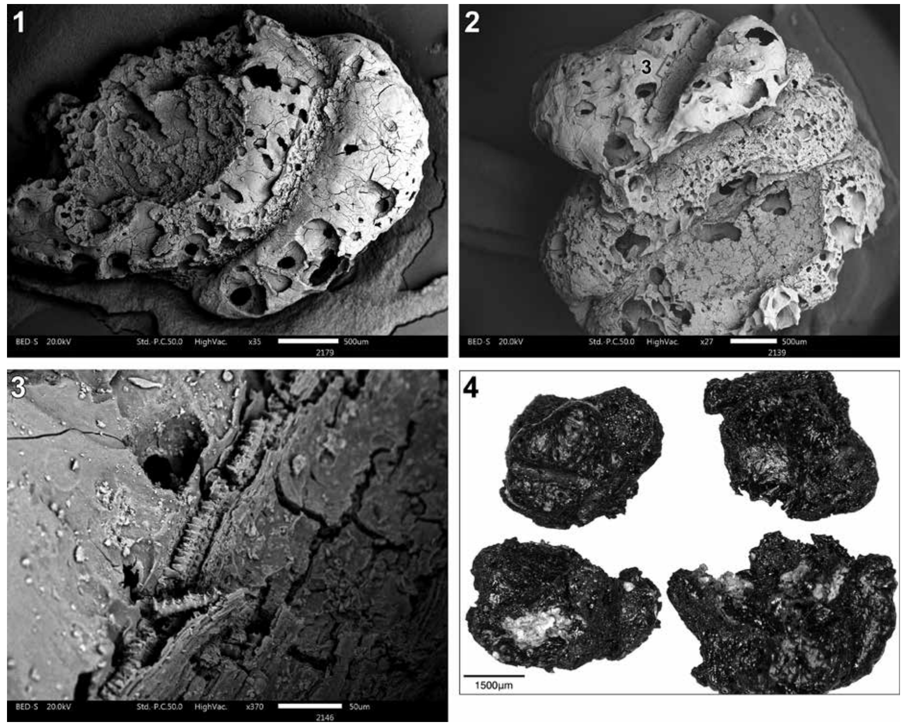

Fig. 6.6 SEM micrographs and stereomicroscope images of charred plant aggregates from Aktopraklık (square 20K) show the presence of a mixture of fused cereal grain in cracked/coarse ground form. 1 Specimen with eroded aleurone layer; 2 Specimen with fused grains, one of which likely cracked; 3 Close-up of 2 showing the ventral furrow; 4 Stereomicroscope images of charred plant aggregates from the same samples showing variable states of preservation, some likely due to high temperature burning and/or high moisture content.

forks when compared to cereal grain, with low quantities of small weed/wild seeds (Percival 2019). The proportions of cereal chaff, grain and wild/weedy seeds observed in the preliminary investigations of indoor contexts suggests the storage of glume wheats as semi-clean ears, and that the archaeobotanical composition of indoor floor deposits represent the cleaning waste derived from the hand-cleaning of glume wheats prior to cooking (cf. Hillman 1984). These initial observations agree with glume wheat storage and cleaning/cooking practices reported at other Neolithic sites in Anatolia (Bogaard et al 2017, 2021). Further spatial analysis and evaluation of sample composition at Aktopraklık will permit a more comprehensive evaluation of crop processing routines at the site, and whether large-scale communal crop processing was widely practiced across the excavated sectors of the site. In addition, ongoing SEM analyses of the charred plant aggregates found in almost all contexts sampled at Aktopraklık will provide further insights into possible spatial variation in the types of plant foods prepared and consumed in outdoor and indoor contexts including different ingredients, preparation routines and recipes. The presence of several large ovens in outdoor/communal areas is suggestive of communal cooking and/or food consumption events. Alongside the evidence for differential crop processing signatures, this evidence might indicate specific cultural practices (e.g. culinary customs) associated with crop production and consumption at the site.

Another significant aspect of the first results of renewed archaeobotanical work at Aktopraklık is the now fully confirmed evidence for the cultivation of a diverse cereal and legume crop assemblage alongside flax. This evidence is in agreement with the emerging archaeobotanical record from northwest Anatolia. Previous work carried out at Late Neolithic and Early Chalcolithic Ilıpınar and Barcın Höyük point to the use of a similar range of crops, alongside fruit and nuts collected from the wild. While we still do not have data from the Neolithic phases at Aktopraklık, on currently available evidence it appears that NGW was present at the site from at least the Early Chalcolithic period. Overall, the NW Anatolian archaeobotanical record (even if incomplete) points to the possible existence of similar crop and wild plant preferences, and woodland catchments through the Neolithic and Early Chalcolithic periods. Ongoing archaeobotanical and anthracological analyses at Aktopraklik will be supplemented by a comprehensive crop $\delta^{13}C$ and $\delta^{15}N$ isotope analysis programme, in order to address cultivation practices (e.g. water availability, manuring) and the contribution of crops to the local subsistence economy.

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Chapter 7

New bioarchaeological approaches to the study of plant food practices in the Eastern Mediterranean during the 2nd millennium BC

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Abstract

Studies of 2nd mill BC culinary practices have usually been based on the rich inventory of archaeobotanical, textual, and pictorial sources, but have suffered from the uneven distribution of the evidence, depending on regional research traditions. Recently, novel bioarchaeological methods such as organic residue analysis (ORA) and isotope analyses have increasingly been applied in Eastern Mediterranean archaeology but have not yet been fully integrated with traditionally available sources. Within the ERC Starting Grant project *FoodTransforms: Transformations of Food in the Eastern Mediterranean Late Bronze Age*, we aim to generate new insights into individual culinary practices by applying a comprehensive bioarchaeological tool kit to the study of food remains from human dental calculus. Through Thermal Desorption-Gas Chromatography-Mass Spectrometry, Proteomics, and Polarising Microscopy, we study traces of lipids, biomarkers, proteins, and microremains trapped in human dental calculus. In our contribution, we will first summarise the traditional approaches and introduce our new ones, which have rarely (or never) been applied in the Eastern Mediterranean before. Subsequently, we will merge the preexisting datasets and our newly created ones in order to provide new insights into plant food and drink in selected regions of the Eastern Mediterranean during the Late Bronze and Early Iron Ages. Finally, we will highlight the great mobility of plant foods and the sophistication of culinary practices in correlation to status and social belonging.

Keywords: *bioarchaeology, food, Eastern Mediterranean, Bronze Age, Early Iron Age*

7.1 Introduction and research questions

Ancient Mediterranean cuisine has long been perceived as a timeless constant, already linking different bordering societies by the 2nd mill BC. The geographic framework was considered essential, whereas intercultural entanglements as transformative factors have been neglected. However, the different elements perceived as hallmarks of the Mediterranean diet (olive oil, wine, wheat bread, etc) were developed in specific regions and then spread through human agency (Horden and Purcell 2000; Broodbank 2013). Within the ERC Starting Grant project *FoodTransforms: Transformations of Food in the Eastern Mediterranean Late Bronze Age* under the direction of Philipp W. Stockhammer, we aim to show the deep and transformative impact of early

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Fig. 7.1 Human dental calculus of a middle-aged male at the Medieval site of Dalheim, Germany (© Christina Warinner).

globalisation on the Mediterranean diet. In order to reach this goal, we trace regional differences in Eastern Mediterranean cuisines during the 2nd mill BC, as well as their transformation in time by focusing on individual diets. Within FoodTransforms, we analyse food remains (lipids, proteins, aDNA, phytoliths, starches, etc) trapped within human dental calculus (Fig. 7.1) of individuals from the Aegean, the Levant, and Egypt during the 2nd mill BC.

After four years of data generation, we are now evaluating that data, and the first methodological and archaeological insights into individual dietary habits have already been published (Mann et al 2020; Scott et al 2021). In order to integrate our results, we compiled the current state of knowledge on past culinary practices for those four regions where our dental calculus samples come from: namely, the Aegean (Tiryns, Chania), the Southern and Northern Levant (Alalakh, Kamid el-Loz, Megiddo, Tel Erani), and Egypt (Abusir el-Meleq, Thebes). In addition to human dental calculus, we also study food remains in pottery with the help of ORA and a particular focus on vessels from Egypt with food labels in Hieratic in order to better understand food terms, which, thus far, could only be read, but not understood.

In the following, we present an overview of our present knowledge on food practices and cuisines in the four relevant regions during the 2nd mill BC, thus encompassing the Middle (MBA) and Late Bronze Ages (LBA), as well as (part of) the Early Iron Age (EIA), integrating the available datasets with the state of analyses of FoodTransforms.

7.2 Sources and methods

Source materials for Bronze Age plant food of the Mediterranean region are distributed uneven in space and time, fragmentarily preserved, and only rarely come from telling contexts, which imposes severe restrictions on interpretation. We compiled a summary of available sources and the possible evidence for storage, processing, transport, consumption, and ritual use of plant foods (Table 7.1).

Although there is considerable evidence for the preparation and consumption of plant foods, the data are usually limited to easily traceable species surviving as impressed, carbonised, desiccated, or mineralised seeds (spices, drugs), grains (cereals, legumes), or small fruits (e.g. berries). Due to the virtual absence of waterlogged deposits in the research areas (e.g. Megaloudi 2006, 23), other plant foods and drinks remain virtually invisible, e.g. tubers, bulbs, fibres, twiglets, leaves, flowers, and similar tissues of a softer, moister, and more perishable nature (Haldane 1990, 56; Murray 2000a, 509; Langgut et al 2016, 382). For a long time, these limitations gave scholars a false impression of prehistoric foodways as being very basic (Stockhammer 2016). However, as Sherratt (1991, 221) phrased it so perfectly: “people don’t eat species, they eat meals”. Another problem is that, in line with the functionalist approaches of Processual and New Archaeology, studies have long focused on subsistence (means exploited to meet vital needs), nutrition (the adequacy of food quality, quantity, and balance), and diet (what is eaten and drunk habitually) (Papathanasiou

Type of source	Possible evidence	St	Pr	Tr	Co	Ri	Examples of relevant publications
Texts	offering lists, storage lists, letters, tales, recipes, provisions for travellers	x	x	x	x	x	Murray 2000a and b; Peters-Destéract 2005; Milano and Bertoldi 2013, 261-326; Brunke 2013; Michel 2013; Fischer 2017a and b
Images	murals, sculpture, models (in temples, graves, palaces, houses)	x	x	x	x	x	Möbius 1933; Murray 2000a and b; Peters-Destéract 2005; Robins 2016; Yasur-Landau et al 2018, 329
Archaeobotany	micro and macro remains (desiccated, mineralised, carbonised, waterlogged, impressed), micro fossils (pollen, phytoliths, starch granules, opaline phytoliths, calcitic wood ash pseudomorphs, dung spherulites)	x	x	x		x	Vickery 1936; Kroll 1982, 1984, 2019; Riley 1999; Vaughan and Coulson 2000; Murray 2000a and b; Valamoti 2003; Stika and Heiss 2013; Gur-Arieh et al 2014; Vetters et al 2016; Fischer 2017 and b; see also Tab. 7.2
Processing equipment	mortar/pestle, quern, hearth +/- pebbles, oven (tanur/tabun), "souvlaki grill/tray", "clay crust", spit, plaster basin, oil press (smaller basins), wine press (larger basins), brewery		x		x		Frankel 1999; Murray 2000a and b; Vitelli 2000, 12; Marigliano 2013; Gur-Arieh et al 2013; Fischer 2017a; Gur-Arieh 2018; Stockhammer 2018
Storage facilities	rooms with storage containers (pottery, organic), granaries, storage pits	x		x			Blegen and Rawson 1966; Murray 2000a and b; Hagenbuchner-Dresel 2002, 8-9; Wiese and Jacquat 2014, 134 cat. 8A; Diffey et al 2017; Yasur-Landau et al 2018
Fuel	grass, dung, wood, charcoal, lignite, olive oil cake		x				Murray 2000a, 510; Sarpaki and Ascouti 2008, 370-371; Brogan et al 2013; Livarda and Kotzamani 2013, 24; Vetters et al 2016, 105; Gur-Arieh et al 2014; Buckley et al 2021
Food processing	boiling (pit, hearth, lipids at vessel tops), simmering (hearth, lipids at vessel bottoms), roasting (hearth, oven, grill), baking (plate, oven), salting/pickling, confit, drying, grinding, pounding, grating, soaking, leaching, pressing, fermenting, rotting		x		x		Murray 2000a and b; Yasur-Landau 2001; Lis 2006/2007, 2017b; Stockhammer 2008; Gur-Arieh et al 2012; Hastorf 2017, 91-106; Gur-Arieh 2018
Pottery	characteristic shape (spout, handle(s), loop(s), stem, omphalos, jar, tripod, grater...), soot marks, Organic Residue Analyses (lipids, fermentation markers)	x	x	x	x	x	Yasur-Landau 2001; Lis 2006/2007, 2017b; Ben-Shlomo et al 2008; Ben-Shlomo 2011; Gur-Arieh et al 2011; Tzedakis and Martlew 1999; Tzedakis et al 2008; Stockhammer 2006, 2008
Human bones, teeth, dental calculus, faeces	isotope analyses for plant:meat ratio (N 14/15), sea-food and C3/C4 plants (C 12/13), climate (O 16/18), migration (Sr 86/87), rainwater vs spring water (H 1/3), distance from sea (S 34/32), species consumed or inhaled (according to seeds, fibres, phytoliths, pollen, starch, proteins, lipids, DNA)				x		Riley 1999; Vaughan and Coulson 2000; Tzedakis and Martlew 1999; Tzedakis et al 2008; Richards and Hedges 2008; Voutsaki and Valamoti 2013; Papathanasiou et al 2015; Nafplioti 2016; Langgut et al 2016; Spiteri et al 2019
Evidence for transport of/ trade in plant foods	wrecks (pottery containers, baskets, bags, strainer tips), botanical evidence outside area of provenance	x		x	x		Haldane 1990; Bass 1991; Serpico et al 2003; Stern et al 2003, 2008; Yalçın 2005; Namdar et al 2013, 2015; Gilboa and Namdar 2015; Shai et al 2019; Linares et al 2019

Table 7.1 Sources on ancient plant food practices, with a focus on the 2nd mill BC Mediterranean region (St = storage, Pr = processing, Tr = transport, Co = consumption, Ri = ritual).

and Fox 2015, 1-2). Later on, Postprocessual approaches introduced semiotic perspectives into food studies, thus emphasising food, and especially feasting, as a means of symbolic communication. However, the current discipline of Food Studies long ago shifted to different perspectives understanding food as a sensual experience of taste, a joy, the creation of memories and authenticity, etc (e.g. Hamilakis 1998; Hastorf 2017). Stockhammer (2016) argued that past food studies need to take these approaches into account in order to better embrace the topic. Here, the concept of cuisine becomes relevant, which implies a certain practice or even art of cooking involving distinctive ingredients, gadgets for processing, serving, and eating, cooking equipment and techniques, installations, and dishes, structured by and contributing to social discourses, and usually associated with a certain society or geographic region (Valamoti 2009a, 33; Farrer 2015, 4-7). Eastern Mediterranean Bronze Age rulers, for example, were so devoted to their local foodways that they even travelled with their personal cooks and precious vessels (Michel 2013, 313), which might also have helped to avoid being poisoned.

In reconstructing past cuisines, the sheer lack of surviving or retrieved plant remains is aggravated by our fundamental ignorance of recipes. This lack is not really compensated for by the – admittedly existing – texts, such as the Egyptian late 16th c BC Ebers Papyrus (Stuhr 2014) with its nearly 900 recipes for wholesome plant-rich foods and beverages, which do not usually include information on the quantities of ingredients, however. Egyptian models and murals illustrating baking and brewing provide a few additional details, e.g. cone-shaped loaves of ground tigernut and honey (15 c Tomb of Rekhmire TT 100: Rekhmire 2020; Eng 2020) or emmer bread leavened with verjus and sweetened with dates (12 c Tomb of Ramesses III KV11: Gurevich 2018; Eng 2020; https://www.ramesses-iii-project.com/english/the-project/).

Within the Hittite Empire, the plant food evidence from well-dated cult inventories of ritual offerings at urban festivals, palace inventories, vows, and oracle texts provide important insights (Hazenbos 2003, 3-9). If we accept that the subsistence of the Hittite gods reflected the dietary habits of the mortals worshipping them (Hoffner 1974, 213-215; Hagenbuchner-Dresel 2002, 1), we may infer that plant foods played a major role in the composition of well-balanced meals. Possible combinations were, for example, mutton with different breads, barley porridge, bread pudding, cheese, fruit, and beer (*Catalogue des Textes Hittites 330*), raw and cooked mutton with leavened bread, fat pastry, fruit, and beer (*CTH 525.3*), raw and cooked beef and mutton with different breads, bread pudding, cheese, wine, and beer (*CTH 525*), beef and mutton with groats, different breads, barley and wheat porridges, fat cake, wort, and beer (*CTH 530*) (Hazenbos 2003, 38-39; 44; 110-111; 114-115; 130), oily soup and *walḫi-* or *tawal*-drink (*CTH 591, 626*), tooth-shaped bread, cheese, fruit, and (sour?) milk (*CTH 631*), or unleavened bread topped with liver and accompanied by an unspecified drink (*CTH 647*) (Barsacchi 2019, 7-12; cf. also Beckman 2011, 98). It is noteworthy that, in the neighbouring kingdom of Ugarit, plant food products, e.g. grain and wine, accounted for only some 6% of mentions of the 92 different kinds of religious offerings, far outmatched in number (and presumably value) by meat (54%) and textile (18%) offerings (Pardee 2002, 224-225). In this case, it seems unlikely that the meat-biased divine diet reflected the average human consumption.

We also gain a glimpse into Hittite recipes for bread, in particular from these textual sources: they were made from barley, wheat, or leguminous flour and involved thick leavened (yeast or sourdough) or thin unleavened breads, large or small loaves, different colours (white, black, red-brown), and sweet, salty, sour, bitter, or spicy varieties. *Iduri* bread, for example, was made from draff, flour, goat's blood, and sheep fat. There were also honey bread, pomegranate bread, fig bread, cucumber bread, fatty/oily bread, and cake, bread made from big peas or with the unidentified *AN.TAH.ŠUM* plant (saffron?, cf. Hoffner 1974, 109-110), bread soup, and bread pudding. Icing with honey and toppings or stuffings of cheese, vegetables, and/or fruit are also attested, such as *wišta* pastries filled with apple or honey (Hagenbuchner-Dresel 2002, 12; 15; 21-23; 26-27; 60; 168; 172; cf. also Kiliç et al 2017, 142; 145-146). Even the approximate amounts of main ingredients can be assessed, and the usual weight of breads have been calculated at some 60-65 g, 120-130 g, 240-260 g, or 480-520 g (Hagenbuchner-Dresel 2002, 35-50; 62), i.e. between a present-day roll and small bread loaf. An important aspect of these culinary efforts at Hittite festivals, such as the autumnal three-day KI.LAM "Gatehouse Festival" at Hattusa, was the (re)unification of the city community through the collection, preparation, and redistribution of food. The cuneiform evidence allows for an estimate of individual daily rations of a (small?) share of meat, 1 kg of bakery products, two jugs of beer, and some low quality wine, the good wine being reserved for rituals (Singer 1983, 124; 126; 133; 157-163).

Even more precise information comes from the cuneiform Yale Tablets (ca 1700 BC), with true recipes for elaborate dishes, but again without quantities and, thus, rather meant as memory aids for experienced specialists than for the Every(wo)man (Bottéro 1985; 1987; 2004). In the Aegean, the food and spice tablets from Knossos (F and Ga series), Pylos (Fr and Un series), and Mycenae (Oe and Ge series) are of significance to dietary studies but do not contain recipes (Bennett 1953; Finley 1957, 130; 136 note 4; Chadwick 1972, 25-26; 31; Knapp 1991, 42; Fischer 2017a, 155-156). Yet, there is archaeobotanical evidence from Greece from around 2000 BC indicating possible recipes for instant foods similar to *bulgur*, boiled and dried wheat groats, and *trachanas*, dried lumps of (fermented?) cooked groats (Valamoti 2002; 2003, 99; 2009a, 32-33; 2018, 7).

Food crusts and human excrement give some insights into individual dietary practices. In ancient Israel, there is plant food evidence from human faeces in LBA cesspits at Megiddo, Hazor, and Tell el'Ajjul. The pollen found in the LB IIA (14th c BC) faeces from an administrative building near the palace of Megiddo reflects a wide variety of species. There is evidence for cereals, olive (oil), fig, edible *Gundelia* thistle, grapes (as fruit/raisin/must/wine/vinegar/syrup?), and dishes/drinks/drugs including mint, sage, myrtle, nettle, poppy, and chamomile or honey collected from these (Langgut et al 2016, 381-183). Since this evidence accumulated over longer periods, it gives no clues as to individual meals. In Greece, research on human excrement is still in its infancy (Vaughan 2000, 4). To our knowledge, human Bronze Age faeces have only been attested in a Minoan manured field on Pseira Island (Bull et al 2001) but have not been analysed for plant food remains yet.

Apart from a very few exceptions, such as a mural from Tiryns featuring a procession bringing pomegranates (Papadimitriou et al 2015; see also Valamoti 2011; Margaritis 2014), we also lack information on the presentation of Aegean or Levantine Bronze Age foods to either humans (in life or death) or gods. It seems very possible that food offerings, and maybe even mundane dishes, were elaborately decorated like in present-day Hinduism and Buddhism (Fig. 7.2) or in ancient Egypt, Syria, and Mesopotamia.

In the Nile Valley, we encounter elaborately hand-shaped and moulded breads and cakes, e.g. in the Mastaba of Ty at Saqqara from ca 2500 BC, the 15 c Tomb of Rekhmire (TT100), the 14 c Tomb of Kha (TT8), and the 12 c Tomb of Ramesses III (KV11) (Samuel 2000, 563-564; Peters-Destéract 2005, 119-148; Russo 2012; Gurevich 2018; Eng 2020; Rekhmire 2020; https://www.ramesses-iii-project.com/english/the-project/; register 2

Fig. 7.2 Decorative Hindu food offering from Gunung Kawi temple, Tampaksiring, distr. Gianyar, Bali, Indonesia (© Janine Fries-Knoblach).

Fig. 7.3 Scribe Roy and his relatives sitting before a sheave of onions and offering tables piled with decorative breads and vegetables, main register on the north wall, Tomb of Roy (TT255), early 13th c BC (© www.osirisnet.net).

	Greece	Egypt
References	Kroll 1982, 1984, 2019; Knapp 1991, 37, 42-43; Tzedakis and Martlew 1999; Valamoti 2003, 104; 2009a, 2009b; 2013; 2018; Megaloudi 2006; Tzedakis et al 2008; Arnott 2008, 113-115; Morrison 2011; Moody 2012, 250-253; Livarda and Kotzamani 2013; Stika and Heiss 2013a and b; Dewan 2015; Vetters et al 2016; Fischer 2017a and b; Stockhammer 2018	Beaux 1990; Murray 2000a and b; Murray et al 2000; Samuel 2000; Serpico and White 2000a and b; Amigues 2005; Peters-Destéract 2005; Loeben and Kappel 2009; Germer 2011; Kappel and Loeben 2011; Robins 2016; Le Page 2019; Shahat and Jensen 2020
Cereals and other starchy plants	hulled barley (mainly six-rowed, *some two-rowed, some naked*), einkorn (mainly N-Greece), emmer (mainly S-Greece), broomcorn millet, spelt, bread and/or durum wheat; *some finger millet, foxtail millet, wild foxtail millet, Polish millet, Timopheev's wheat; rarely bromes, (wild) buckwheat, (wild) oats, rye, (rice?)*	hulled four- and six-rowed barley, emmer; *some einkorn, two-rowed barley, free-threshing wheat, sorghum, (eelgrass seeds?)*
Pulses	fava been, lentil, pea, grass pea, bitter vetch; *some lucerne, chickpea, red pea, wild pea, Cyprus vetch/cream pea, garden vetch, Spanish vetchling, (lupin?)*	lentil, pea, chickpea, cowpea; *some fava bean*
Vegetables	fava bean, birdweed, wild buckwheat, caper, celery, cleavers, false cleavers, cornsalad, cress, echium, fennel, fenugreek, garlic, goosefoot, field gromwell, leek, lucerne, mallow, mustards, pea, pink, plantains, purslane, wild radish, sesame, sorrel, cotton thistle, *(beet, burnet, campion, carrot, chicory, chrysanthemum, clover, cucumber, canary grass, heron's bill, honeysuckle, nettles, orache, parsnip, true sedges, tigernut, willow?)*	dragon arum, fava bean, water caltrop, caper, celery, centaury, chicory, chrysanthemum, cress, cucumber, desert date (balanites), Eminium spiculatum, fenugreek, garlic, gourd, sponge gourd, leek, lettuce, lotus, moringa, okra, onion, spring onion, papyrus, pea, Assyrian plum, radish, sesame, Narbonne star-of-Bethlehem, taro, tigernut, *(aubergine, eelgrass, pondweed, great willowherb?)*
Fruits	acorn, almond, apple, crabapple, blackberry, caper, Cornelian cherry, chestnut, elder, dwarf elder, fig, goosefoot, (wild) grape, European and Oriental hackberry, hawthorn, linseed, mallow, myrtle, olive, (wild) pear, sesame, sloe, strawberry, terebinth nut, walnut, *some melon, pomegranate, (carob, date, pine nuts, pistachio, plum, quince?)*	almond, caper, carob, bitter cucumber, date, argun date, desert date (balanites), doum date, Eminium spiculatum, fig, sycamore fig, grape, linseed, melon, myrtle, nabq (Christ's thorn jujube), olive, persea (mimusops), pistachio, pomegranate, Assyrian plum, sesame, snot berry, Jerusalem thorn, watermelon
Oil plants	almond, olive (mainly S-Greece); gold of pleasure, linseed (mainly N-Greece); dragon's head, opium poppy; *some field gromwell, safflower, sesame, terebinth, (cress, melon, pine nuts, common poppy, horned poppy, tigernut, walnut?)*	almond, bitter cucumber, desert date (balanites), gourd, sponge gourd, lettuce, linseed, lotus, melon, moringa, nabq (Christ's thorn jujube), papyrus, olive, ricinus, safflower, sesame, terebinth, tigernut, watermelon, *(cress, opium poppy?)*
Spices/medicinal plants	aniseed, asphodel, bay laurel, marsh-bedstraw, field bindweed, birdweed, borage, caper, cardamom, celery seed, cleavers, cistus, clover, coriander, cumin, cyperus, poison darnel, dragon's head, echium, elder, dwarf elder, fennel, fumewort, garlic, germander, field gromwell, European and Oriental hackberry, harmal, hawthorn, henbane, honey, iris, juniper, lavender, lime blossom, linseed, liquorice, lucerne, mallow, melon, annual mercury, milkvetch, different mints, mustards, myrtle, black nightshade, pine resin, pink, narrowleaf plantain, water plantain, pomegranate, common poppy, horned poppy, opium poppy, purslane, rose, rue, safflower, saffron, sage, sesame, speedwell, sumac, shaggy sparrow-wort, sun spurge, terebinth resin, thyme, vervain, wormwood, St. John's wort, *(arundo, lemon balm, beet, burnet, calamus, campion, carob, chrysanthemum, clover, sweet clover, dill, dog's tooth grass, fenugreek, henna tree, heron's bill, ivy, knotweed, mullein, nettles, pennyroyal, pheasant's eye, primrose, sandspurry, summer savory, violet, willow?)*	Egyptian acacia, dragon arum, lemon balm, bindweed, cannabis, carob, cassia, celery seed, true camomile, chrysanthemum, cinnamon, coriander, cress, cyperus, bitter cucumber, cumin, black cumin, desert date (balanites), doum date, dill, sword-leaf dogbane, fenugreek, frankincense, garlic, wild ginger (Siphonochilus aethiopicus), poison gooseberry, honey, iris, juniper, linseed, lotus, mandrake, milkvetch, moringa, myrrh, myrtle, nabq (Christ's thorn jujube), onion, papyrus, pepper, persea (mimusops), Assyrian plum, pomegranate, pondweed, safflower, Indian sage, senna, sesame, snot berry, soapnut, strychnine tree, tamarisk, terebinth resin, Jerusalem thorn, willow, *(centaury, ivy, bay laurel, kurrat/wild leek, common poppy, opium poppy, great willowherb?)*
Beverages	barley beer, wheat beer, wine, spiced wine, fruit wine, mead, mixed fermented beverages, *(brandy?)*	emmer beer, wine; *also fruit wines, palm wine*
Remarks	no pulses in Linear B tablets	no pulses as grave offerings or in pictures

Table 7.2 Overview of 2nd mill BC evidence for plants with food potential in Greece, the Southern Levant, Egypt, and the Hittite Empire by common names in alphabetical order. Rare species in italics, uncertain attestations in parentheses. For scientific names see Plant list.

in: https://www.osirisnet.net/mastabas/ty/e_ty_04.htm). There are also onions artfully braided into bell-shaped sheaves, e.g. in the 13 c Tomb of Roy (TT255) (Roy 2021, 2; cf. Peters-Destéract 2005, 30 fig. 22b; 280 fig. 298; colour pl. 2), pottery vessels adorned with real or painted flower garlands (Florists 2018), and ornate sacrificial tables (Fig. 7.3) (e.g. Roy 2021; cf. Murray 2000b, 611 fig. 24.1; Peters-Destéract 2005, 343 fig. 338; 353 fig. 348; Wiese and Jacquat 2014, 83 fig. 6; Robins 2016, 119 fig. 5).

Ancient Egyptian floristry abounded with breath-taking creations, such as bouquets, flower garlands and collars for the living, and mummy garlands and wreaths for the dead (Loeben and Kappel 2009, 161-173; Kappel and Loeben 2011, 48-77; Heilmeyer 2011, 78-86; Germer 2011, 134-146; Wiese and Jacquat 2014, 34-40; Florists 2018). Decorative arrangements such as these must have made any meal or feast, mundane or funeral, an impressive display for the eyes, difficult to reconstruct from modern archaeological and scientific evidence. The same may be true for the scent of dishes, which not all people participating in a feast might have had the privilege to taste (Fox 2008, 135-136; Lis 2017a, 211).

The Hittites' aforementioned fondness for bakery products resulted in breads, rolls, cakes, cookies, and pastries shaped into curls, crescents, wreaths, sticks, discs, or little sculptures, such as humans, animals (sheep, pig, cattle, snake, etc), fruits (bunch of grapes, pomegranates, etc) or body parts (tooth, tongue, ear, etc); unlike Egypt or Mari, no moulds have yet been found, so they were probably hand-shaped (Hagenbuchner-Dresel 2002, 2, 10, 22-25, 60). At Hittite-occupied 13 c Emar, religious festivals involved arranging dozens of elaborate bread types, e.g. with fruit, and tiny beakers before the deity, and this careful "handling contributed essentially to distinguish a ritual sacrificial meal from everyday food consumption" (Sallaberger 2015, 194).

For Mesopotamia, the aforementioned Yale recipes (Bottéro 1985, 1987, 2004) indicate that dishes were not only refined by various vegetables and spices but also

Southern Levant	Hittites
Haldane 1993, 357; Namdar et al 2010, 2015; Frumin et al 2015, tab. S2; Langgut et al 2016; Yasur-Landau et al 2018; Linares et al 2019; Kislev et al 2020; Scott et al 2021	Hoffner 1974; Knapp 1991, 46; Ünal 2005, 168-169; Müller-Karpe 2005; Arnott 2008, 113-115; Beckman 2011, 99; Sallaberger 2015; Rössner 2016; Diffey et al 2017; Kiliç et al 2017, 142, 145, 150; Fairbairn et al 2019
different barleys, einkorn, emmer, wheat; *some millet, wild oats, wild sawa millet, wild teff*	barley (mainly two-rowed, also six-rowed, hulled and naked), einkorn, emmer, bread wheat, club wheat; *some wild barley, wild buckwheat*
fava bean, soya bean, lentil, pea, chickpea, grass pea, hairy cowpea, bitter vetch, Spanish vetchling	fava bean, chickpea, grass pea, Lathyrus sp., lentil, pea, bitter vetch; *some lucerne*
fava bean, beet, cabbage, caper, celery, cornsalad, cowherb, crown daisy, devil's thorn, clustered dock, fiddle dock, echium, false fennel, fenugreek, goosefoot, nettle-leaved goosefoot, heron's bill, mallow, marigold, black mustard, black/red nightshade, pea, monk's pepper, plantains, prickly scorpion's-tail, seepweed, sesame, sorrel, corn spurry, Gundelia thistle, *(bellevalia, tigernut?)*	fava bean, wild buckwheat, campion, carrot, centaury, cowherb, cress, watercress, garlic, goosefoot, field gromwell, leek, lettuce, hill mustard, onion, bitter onion, parsley, pea, sesame, sorrel, (*cucumber, pondweed?*)
acorn, almond, apricot, banana, blackberry, caper, date, fig, sycamore fig, goosefoot, grape, European hackberry, hawthorn, linseed, mallow, Syrian mesquite, myrtle, black/red nightshade, olive, monk's pepper, Atlantic pistachio, pomegranate, sesame, walnut	acorn, almond, apple, apricot, black-/raspberry, date, elder, fig, goosefoot, grape, Oriental hackberry, hawthorn, hazelnut, linseed, pear, pistachio, plum, olive, pomegranate, sesame, sloe, terebinth nut, walnut, *(Cornelian cherry, medlar, melon, pear?)*
almond, linseed, monk's pepper, olive, seepweed, sesame, soya bean, terebinth, walnut, *(tigernut?)*	gold of pleasure, hazelnut, dragon's head, linseed, olive, horned poppy, sesame, walnut, *(cress, field gromwell?)*
babe's breath, bay laurel, beet, caper, cedar, celery seed, camomile, cinnamon, corn cleavers, hare's-foot clover, sweet clover, coriander, cowherb, hairy cowpea, cranesbill, cumin, cyperus, poison darnel, echium, Erucaria microcarpa, false fennel, fenugreek, fumewort, germander, nettle-leaved goosefoot, hare's ear, hawthorn, European heliotrope, heron's bill, honey, iris, jasmine, juniper, common knotweed, linseed, little mallow, marigold, annual mercury, Syrian mesquite, milkvetch, mint, white/black mustard, myrtle, nailwort, nettle, black/red nightshade, nutmeg, onosma, monk's pepper, scarlet pimpernel, Atlantic pistachio, plantains, pomegranate, opium poppy, reseda, ribwort, sage, prickly scorpion's-tail, sesame, little sparrow-wort, shaggy sparrow-wort, speedwell, storax resin, terebinth resin, Mary thistle, turmeric, vanilla, vervain, wormwood, *(valerian, saffron?)*	asafoetida, bedstraw, bindweed, bugleweed, campion, cedar resin, centaury, coriander, corn cleavers, cowherb, cress, watercress, cumin, black cumin, dill, dragon's head, elder, fennel, fenugreek, germander, Oriental hackberry, hare's ear, hawthorn, European heliotrope, henbane, honey, prickly juniper, knotweed, linseed, hill mustard, black nightshade, onion, parsley, pink, pomegranate, horned poppy, saffron, sesame, sparrow-wort, ivy-leafed speedwell, spurge, sumac, *(juniper, tamarisk?)*
beer, wine	barley beer, beer concentrate, knotweed beer, beer with fruit and soured milk, marnuwan beer/cocktail, wine, *(walḫi, tawal, and limma alcohol?)*

nicely arranged and decorated with little breads and chopped herbs such as coriander (e.g. Bottéro 1985, 44; 1987, 17; 2004, 28-29). The same is true for Hittite festival rituals, where king or priests offered sacrifices consisting of, for example, a bread loaf sprinkled with cheese, honey, grapes, and flour (*CTH 647.II 2i*: Taracha 2017, 33-34). For the Aegean, we may assume that saffron was not only collected for the sake of its flavour, scent, and health benefits, but also in order to colour foods and drinks in a gold-like, yellow-orange hue, perhaps as a sign of high status (Arnott 2008, 114; Day 2011, 367; Zohary et al 2012, 165).

Recently, scientific methods have provided important further insights into past food practices. The most important ones are Organic Residue Analyses (ORA) in pottery and dental calculus with the help of Gas Chromatography-Mass Spectrometry – sometimes combined with Thermal Desorption and/or Pyrolysis and Proteomics to target fragmentary proteins in calculus and vessels, Polarising Microscopy in order to identify microremains like phytoliths and starches in sediment and calculus, and stable isotope (C, N) analyses. Isotope analyses have been applied for more than a decade in the Eastern Mediterranean (Richards and Hedges 2008; Voutsaki and Valamoti 2013; Papathanasiou et al 2015), but recently, ORA has become much more prominent, with case studies all over the region (Tzedakis and Martlew 1999; Serpico et al 2003; Stern et al 2003; 2008; Guasch Jané et al 2004, 2006a, 2006b; Tzedakis et al 2008; Namdar et al 2010; 2013; 2015; Gilboa and Namdar 2015; Linares et al 2019; Shai et al 2019; Arie et al 2020). In contrast, proteins and microremains in calculus have not been studied in the Eastern Mediterranean Bronze and Iron Ages before.

7.3 The pre-existing evidence

In the following, we will mainly focus on LBA Greece and the Southern Levant, as these have provided the most varied bioarchaeological evidence in the region, including enormous datasets from archaeobotany (e.g. Frumin et al 2015; Kroll 1982, 2019; Megaloudi 2006; Valamoti 2009b) and ORA (see above). These give evidence for cereals, pulses, vegetables, fruits, oilseeds, spices and medicinal/psychoactive plants (leaf, seed, root, wood), and beverages (juices, saps, alcohols, vinegars). Here, we present a compilation of plants with food potential available at the time and attested at important sites, only differentiating between current and rarer species, though checking the extent to which each of the plants was indeed consumed in a specific context is not currently possible. To this information, the evidence from written sources and pictorial representations was added. The criterion for the inclusion of wild species were their nutritious and/or medical properties, although we are well aware that “presence and knowledge ... do not necessarily suggest intensive exploitation” (Livarda/Kotzamani 2013, 23). Nevertheless, it seems important to us to list them so that they can systematically be searched for in relevant databases in future Proteomics, starch, or phytolith studies. In this paper it was neither possible nor intended to include every single publication in existence, but rather to give a general impression of the nature of the datasets and an overview of what was available (following Megaloudi 2006, 23; Valamoti 2009a, 33) in our focus areas and in Egypt and the Hittite Empire for comparison (Table 7.2).

For the Levant, there is a remarkable list of 178 attested plant species and genera from 18 Bronze Age settlements (Frumin et al 2015). The spectrum of four main cereals coincides with Egypt, except for the occasional presence of sorghum, and both are much more homogeneous than Greece, with its regional diversity of grain species. Legumes are nearly as numerous as in Greece and more various than in Egypt or the Hittite Empire. The Southern Levant and Greece abound in both cultivated and collected vegetables and spices/medicinal plants, which partly reflects the outstanding floral biodiversity of these regions (Megaloudi 2006, 2; 62; Valamoti 2009b; 2012/13; Frumin et al 2015), but may partly be due to biases in the available source material. Last but not least, it might also reflect the existence of “wilderness” and farm gardens between arable areas, unlike the intensively cropped and settled narrow Nile Valley with adjoining xeric areas hostile to many weeds. In the Early Iron Age, 113 new taxa were introduced to the Southern Levant, which has been associated with Philistine immigrants, as these taxa were initially restricted to their settlements, while only two species from Iran, apricot and European nettle tree, first appeared in non-Philistine contexts (Frumin et al 2015, 4-5). Textual information comes from the Story of Sinuhe, an Egyptian nobleman who lived in Canaan around 1900 BC. He praises the beautiful land rich in figs, grapes, wine, honey, olives, fruits, barley, emmer, cattle, milk, fowl, and venison (Sinuhe 81-91) (Blumenthal 1982, 10; Widmaier 2009, 75-76, 151-152).

For Greece, Fischer’s studies (2017a and b, 60-62) are a most useful compendium for plant food use. The Linear B evidence attests to the consumption of cereals (si-to) like barley (ki-ri-ta), fruits (ka-pa) such as olive (ideogram *122), grape (ideogram *131), fig (su), myrtle (mu-to), pistachio/terebinth? (ki-ta-no), pomegranate (ro-a), and possibly date (po-ni-ki-jo), olive oil (to-ro-qa), wine (wo-no), and honey (me-ri), as an animal-made but plant-based food. There are also words for seeds (pe-mo) and spices like celery (se-ri-no), coriander (ko-ri-ja-do-no), cress? (ka-da-mi-ja), cumin (ku-mi-no), fennel (ma-ra-tu-wo), two mints (mi-ta, da-ra-ko), safflower (ka-na-ko), saffron (ko-ro-ki), sage (pa-ko-we), sesame (sa-sa-ma) or sumac (ro-wo), and edible grasses such as *Cyperus*/tigernut? (ku-pa-ro) and calamus? (ko-no) (Tzedakis et al 2008, 203; Fischer 2017a, 16-17, 45-48, 97, 108, 128, 143, 147, 149, 158, 164-165, 168, 171-172, 175, 179-187, 194, 200-201, 205, 318). However, pulses are entirely lacking (Fischer 2017a, 92) and do not seem to have been an object of palatial administration (Halstead 1992; Valamoti 2009b). Bronze Age Greece abounded in cereals, not only primeval eastern ones such as einkorn, emmer, and barley, but also northern, eastern (wheats, spelt, broomcorn and foxtail millet: Kroll 1982, 470; 1984, 212; 2019, 77; Valamoti 2007; 2013), and southern novelties (finger millet/crabgrass: Kroll 1984, 213). At Tiryns, there is the unique find of an uncharred rice husk from a well stratified context, probably preserved due to its high silica (SiO_2) content (Kroll 1982, 469-470 and pers. comm.; the singular occurrence is no argument against it, since the same is true for the staple foods pea and linseed: Kroll 1982, 470). Additional evidence for the consumption of rice in the 2nd mill BC Eastern Mediterranean is provided by an Akkadian cuneiform text from *Kahat*/Tell Barri in Syria, attesting to local irrigated rice fields around 1100 BC (Muthukmaran 2014, 4). Quite astounding is the wealth of about a dozen different pulses (cf. Megaloudi 2006, 52; Stika and Heiss 2013b, 350; Fischer 2017a, 78-85), which enlarged the so-called Mediterranean triad (cereal, wine, olive) into a “Mediterranean quartet” (Sarpaki 1992). The pea, which is found in surprisingly small numbers, might have been preferred half-ripe as a vegetable (Fischer 2017a, 88). Although no date stones have been found in Bronze Age Greece, the contacts with Egypt, the presence of palm phytoliths (Vetters et al 2016, 125-127; for po-ni-ki-jo = date Fischer 2017a, 183-186; 408), seals with prints of palm leaf textiles (Fiandra 1968, 386 pl. Eta; 389–390) and representations of date (Möbius 1933, 15-17 fig. 9; Marinatos 1984, 120; Vetters et al 2016, 125-126) make it likely that (pitted dried?) dates were consumed (idem Fischer 2017a, 185-186). The evidence for many leafy vegetables is reminiscent of modern Greek *khorta*, for which some 80 plant species are supposedly used (Lampraki 1997; cf. Wikipedia), of which at least purslane, fennel, mallow, caper, sorrel, mustards, and thistles are attested in Bronze Age contexts (on Minoan use of wild vegetables: Moody 2012, 251-252). Given the wealth and continuity of representations, saffron must have been a plant of great practical and spiritual value as a dye, spice, scent, incense, cosmetic, and medicine, as can be seen from the fact that it was

Fig. 7.4 Minoan wine press in a country house at Vathypetro, parish Archanes-Asterousia, Crete, 16th/15th c BC (© 2016 Olaf Tausch – Eigenes Werk, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=55282925, unaltered).

the only spice measured by weight – in the same small values as gold (Day 2011; Dewan 2015). For both Greece and the Levant, the absence of onion is remarkable and undoubtedly misleading due to its perishable nature, since the plant was widely used in Mesopotamia (Bottéro 1985), the Hittite Empire (Hoffner 1974, 108-109), and Egypt (Murray 2000b, 628-630). The Oriental oil plant dragon's head (*Lallemantia* sp.) might have arrived in Greece in the context of tin trade (Valamoti and Jones 2010). Species of South Asian origin like cardamom, sesame, melon, and perhaps even cucumber, and African-derived finger millet/crabgrass (*Digitaria* sp.) had already been introduced to Greece by the Bronze Age (Linear B: Knapp 1991, 42-43; Fischer 2017a, 150, 156, 178-179; plant remains: Kroll 1982, 480-481 tab. 2; 1984, 213; Megaloudi 2006, 71, 77; pre-Greek term for cucumber: Fischer 2017a, 213).

With regard to honey, there is evidence for large-scale apiary in the Aegean Bronze Age (Papageorgiou 2016; Fischer 2017a, 317-322; 2017b, 63). This is unsurprising when the utility of wax for illumination (Evershed et al 2000; Moody 2012, 254), medicine, sealing, writing tablets (Mazar et al 2022, 126), and metallurgy is considered (e.g. 2nd mill BC lost-wax casting: Bol 1985, 19-20; Ruiz-Gálvez and Galán 2012, 49) and coincides with the Hittite (Hoffner 1974, 123-124) and Egyptian evidence (e.g. Serpico and White 2000a, 410). A similar importance of beekeeping, and thus honey, in the Levant may be inferred from the fact that entire LBA clay coffins were sealed with beeswax (Namdar et al 2017) and from the large-scale apiary at EIA Tel Rehov (Bloch et al 2010; Ziffer 2016; Mazar et al 2022).

The production of wine and olive oil is documented by numerous pressing installations in both the Levant (Frankel 1999, 36, 51; Onozuka 2012) and Greece. Levantine specimens were rock-built (Frankel 1999, 51), while the Greek examples belong to three types, either two pottery vessels (Fig. 7.4), two stone basins, or a stone basin with a pottery receptacle (Fig. 7.5 and 7.6) (Knapp 1991, 29; Fischer 2017a, 373-374).

Fig. 7.5 Part of a Minoan oil press from the same country house at Vathypetro (© 2016 Olaf Tausch – Eigenes Werk, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=55314183, unaltered).

Fig. 7.6 Artist's impression of a Minoan oil press at work (© Nikola Nevenov).

Resin finds and ORA analyses show that Greek, Egyptian, and Levantine wine was sometimes flavoured and preserved with terebinth resin, pine resin, honey, spices, and oak wood (Pulak 2005, 76-77; Tzedakis and Martlew 1999, 142, 146, 148, 156, 173, 187, 206; Tzedakis et al 2008, 115, 180, 195, Fischer 2017a, 125, 208) and that both white and red wines were consumed (Guasch Jané et al 2006b; for Greece there is at least Neolithic evidence for red wine: Garnier and Valamoti 2016).

Beer had been a staple in Mesopotamia and Egypt (Zarnkow et al 2006; Samuel 2000) ever since the Neolithic and was also produced in 3rd and 2nd mill BC Greece (Tzedakis and Martlew 1999, 162, 167, 186, 207; Tzedakis et al 2008, 201-203; Valamoti 2018, 3, 11). During the Levantine Bronze Age, there is evidence for breweries, straw-tip strainers, strainer jugs, and the appropriation of Aegean kraters for beer consumption with straws (Maeir

Fig. 7.7 Artist's impression of a Minoan storeroom crammed with storage vessels (© Nikola Nevenov).

and Garfinkel 1992; Stockhammer 2011a, 288-289; 2019, 239; Choi 2016, 18; https://www.history.com/news/ancient-egyptian-brewery-unearthed-in-israel). Despite its rather limited shelf life, beer even seems to have been traded overseas, since in an Akkadian text from Ugarit (RS 16.238) the merchant Sinaranu was granted duty-free status on grain, beer, and oil, if his boat came from Crete (Knapp 1991, 21, 37, 42; Fischer 2017a, 408). Storage and handling of wine, oil, and other commodities are reflected by utility rooms with numerous rows of pithoi, amphorae, or jugs both in the Levant, e.g. at Tel Kabri and Hazor (Koh et al 2014; Yasur-Landau et al 2018, 322-329, fig. 4-8), and in Minoan and Mycenaean palaces and houses (Fig. 7.7) (Blegen and Rawson 1966, 342-348, fig. 253-256; Palmer 1994, 143-146, pl. II-IV; Fischer 2017a, 110-111, 363-365). The same is true for large-scale grain storage in vessels, rooms, or pits, often involving the hermetic long-term storage type, in the Hittite Empire and Egypt (Hagenbuchner-Dresel 2002, 8-9; Diffey et al 2017, 12-13).

As to thermal processing of foodstuffs, the Levant shares the Neolithic "bread and oven" tradition with gluten-rich cereals fit for making doughs in contrast to the African "porridge and pot" heritage based on gluten-free cereals (sorghum, millet, teff) (Haaland 2007). Unlike the Northern Levant and Anatolia (Hagenbuchner-Dresel 2002, 18), there is no evidence for ovens in the Southern Levant before the later 2nd mill BC (Eliyahu-Behar et al 2017; Gur-Arieh 2018, 66-67; Fuller and Gonzalez Carretero 2018, 113-114). MBA Levantine cooking pots are represented by straight-sided, flat-based, handmade specimens in the hinterland and rounded vessels in the coastal plain. Both types were to be placed amidst or suspended above the fire, tempered with limestone or shell debris against thermal shock, and had wide mouths for large food chunks (Master 2011, 257). In the 12th c BC, cooking jars of Aegean inspiration with a globular to ovoid body, one or rarely two handles (jar vs amphora), some 20 cm in height, and a disk or ring base were introduced – first at so-called Philistine sites and subsequently all over the Southern Levant (Ben-Shlomo 2011, 276; Ben-Shlomo et al 2008, 226, 228, fig. 3a-d). According to lateral burn marks, these wheel-thrown cooking jars were not placed in the hearth fire but beside it. This position enabled a quicker reduction of heat but required smaller pieces of food, due to the narrow vessel mouth (Master 2011, 262). Decorated Aegean bowl shapes were also imitated in large numbers, because bowls were the universal Levantine vessel type for both eating and drinking (Stockhammer 2013). Aegean kylikes and tripod cooking pots were not appropriated, since they did not match local foodways (Stockhammer 2013; 2019, 242). Cooking was done at fairly low temperatures and in a rather short time indoors on mudbrick hearths or outdoors on pebble hearths, so that tempering for thermal shock resistance was no longer necessary (Master 2011, 262), although some quartz tempering is attested (Ben-Shlomo 2011, 277). Experiments demonstrated that soot marks only occurred in open flames on the oxygen-poor lee side, which caused incomplete combustion (Gur-Arieh

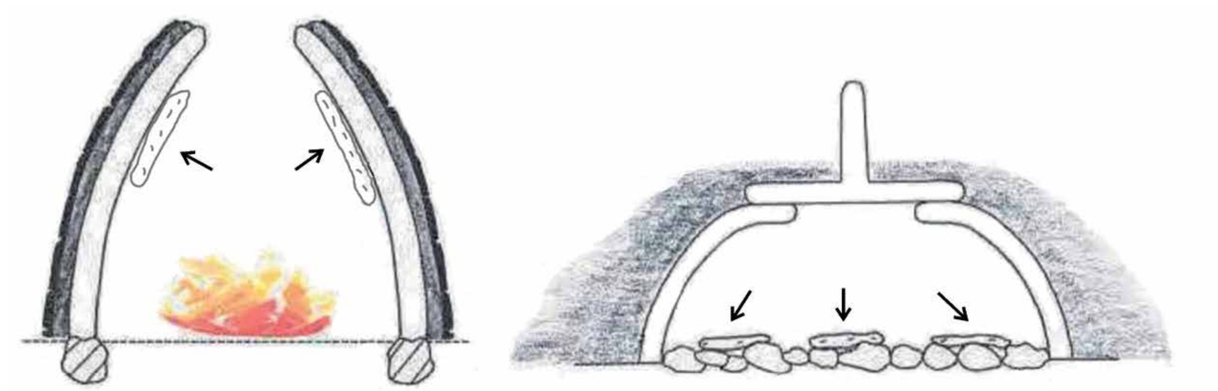

Fig. 7.8 Schematic drawings of a tanur and a tabun oven (© Janine Fries-Knoblach, modified after Gur-Arieh 2018, 68 fig. 4 – drawing Dina Levin).

Fig. 7.9 Modern tanur from Uzbekistan (© Shira Gur-Arieh).

et al 2011, 349, 351). At the same time, there were thick, flat "baking trays" (Ben-Shlomo 2011, 274, 276) and mud ovens for baking, which were built in two types (Fig. 7.8): The first was the cylindrical or troncoconic tanur (Fig. 7.9) with a triple-layered wall on a field stone ring, some 50-80 cm in diameter and 50-70 cm in height. It was fuelled inside with wood or dung, and bread was baked by sticking it to the hot wall. The other was the low, dome-shaped tabun (Fig. 7.10), which was 50-100 cm in diameter with only one wall layer and a lid. It was heated from outside with dung, and bread and cooking vessels were placed on its pebble or tile floor (Gur Arieh 2018, 67-68; Gur-Arieh et al 2012, 2014; generally on tanurs: Rova 2013).

Aegean cooking installations comprised transportable ovens and braziers, as well as built mudbrick hearths, indoors and outdoors, with a plastered pebble or sherd pavement. This sometimes had a central depression for safely placing cooking pots (Stockhammer 2008; 2018, 208; Lis 2008, 150, pl. 26d; Vetters et al 2016; Fischer 2017a, 376, 402; on the Bronze Age shift towards isolated households with private instead of communal storage and cooking: Halstead 1999; Valamoti 2003, 104-106). As ovens and lids are rare in mainland Greece, baking seems to have played a minor role (Hruby 2008, 155; Lis 2015, 111; Fischer 2017a, 375). Mycenaean cooking pots developed from types with a high centre of gravity and narrow splaying foot stabilised by embers towards globular shapes with a broad flat base standing safely on the edge of a plastered hearth. The latter had burn marks opposite the handle (cooking jugs) or on both sides between their two handles (cooking amphorae), which allowed for easy handling for temperature control. In addition to these usually wheel-thrown and thin-walled cooking vessels, Aeginetan potters produced hand-made, thick-walled cooking amphorae which, due to their volcanic tempering, were more suitable for higher temperatures because their thermal conductivity increased thermal shock absorption (Stockhammer 2008, 83-84; Müller et al 2013; Lis 2015). In contrast to other cooking amphorae, the Aeginetan ones were placed in the centre of the hearth, as soot marks on a specimen from Tiryns show (Stockhammer 2008, 322). According to burn marks, and similar to Aeginetan amphorae, tripod cooking pots in Mainland Greece were placed right into the fire, whereby wheel-thrown ones in the usual cooking pot ware and hand-made Aeginetan ones coexisted (Stockhammer 2008).

Fig. 7.10 Modern tabun from Jordan (© Shira Gur-Arieh).

Fig. 7.11 Ancient cooking experiments in replicas of LM I cooking vessels at Papadiokampos, Crete, in 2011. The featured menu was a seafood soup of limpets, top shells, and leeks in olive oil in the flat cooking dish and slowly cooked lentils, honey, and crushed coriander in the cooking pots and tripods. Jerolyn E. Morrison, in collaboration with Chrysa Sofianou, Thomas Brogan, Stefania Chlouveraki, and Jad Alyounis (© Chronis Papanikolopoulos).

At LBA Akrotiri, there was a standard cooking set of an open tripod cooking pot plus a funnel-mouthed jar, both made from volcanic clay with phyllitic temper, which gave them the toughness and good thermal shock resistance expected from cooking pots. The tripods were fired to vitrification, which increased their thermal conductivity suitable for hot boiling or frying; the jars were fired at lower temperatures and were ideal for long-term simmering (Müller et al 2013). At Pylos, there were two sets of vessels, one consisting of a brazier for carrying coals, a tripod, and a flat-based jar for cooking and the other of a shallow pan and a lid for baking. Cooking jars came in two variants, the first with one handle at 90° to a spout, the second with two handles and in two sizes. There were also cooking trays, baking basins, cooking pots with stands ("pyraunoi"[1]), pricked circular baking plates ("griddles"[2]), ladles, sauce boats, mortars, funnels, strainers, graters, and the first plain spit-roasting gear in the shape of pairs of spit supports and square "souvlaki stands" (Tzedakis and Martlew 1999, 90, 97, 102, 134; Maran 2012, 125, 130; Lis 2015, 108; 2008, 146, pl. 24-26; 2017a, 205-206; Fischer 2017a, 380, 383-384, 386, 402; Stockhammer 2018, 208-209). This differentiated set of cooking vessels (Fig. 7.11) points to the existence of complex food preparation practices with different heating techniques and intensities.

Food was usually consumed from deep and shallow bowls. Cups, goblets, and – from LH IIIA2 onwards – kylikes served as drinking vessels (Wright 2004, 138; 140; Fischer 2017a, 384-385) and are usually preserved in ceramic versions, whereas precious metal vessels (gold, silver, bronze) have rarely been preserved outside high-status grave contexts like the Shaft Graves of Mycenae. Grave contexts also preserved sets of valuable bronze containers for preparing and serving food and beverages (such as cauldrons, lekanes, basins, bowls, jugs, pans, hydriai, amphorae, and cups) (Wright 2004, 146-148; 171).

7.4 FoodTransform's newly created data

Despite being informative about general dietary practices, current datasets have hardly enabled us to link these general insights to individual culinary habits. Here, the methodological approach of FoodTransforms – i.e. the extraction of food traces from dental calculus – presents an important step forwards to introduce complexity into our picture of the past by enabling us to target both the individual and the aforementioned plant food types, which usually do not preserve in the archaeological record. It is still unclear why different humans generate calculus in very different amounts, under which conditions lipids, proteins, and microremains are enclosed, and how regularly a particular kind of food needs to be consumed to become embedded (Warinner et al 2014, 2015; Mann et al 2020; Wilkin et al 2020). Therefore, food remains extracted from dental calculus only give evidence that a particular food type was consumed by a certain individual, and it is highly probable that it was consumed several times. Additionally, the identification of lipids, proteins, and microremains requires the existence of reference databases, which are available but concentrate on foods relevant to present-day food companies. Despite all these limitations, we have been able to extract meaningful food remains from calculus, and our work has very much concentrated on the extraction, sequencing, and interpretation of protein fragments and microremains.

Most recently, we published the results of our study of proteins and plant microremains from 16 dental calculus samples from MBA to LBA Megiddo (17th-15th c BC) and EIA Tel Erani (11th c BC) in the Southern Levant (Scott et al 2021). All analysed individuals had preserved microremains of wheat in their teeth, and many also had date. One individual from Tel Erani also provided evidence for the consumption of millet.

Whereas all individuals provided us with a large number of protein fragments after Tandem-Mass Spectrometry, only a few individuals provided fragments that could be securely attributed to a specific known dietary protein, as we followed a rigorous and conservative strategy of eliminating uncertain identifications. It became clear that the chances of preservation and identification were best for either protease inhibitors or proteins from the seed storage protein superfamily, as they are both stable against proteolysis and thermal processing, as well as widely studied, since they are notorious allergens. Protein analyses confirmed this evidence through the wheat protein gluten in one individual from Megiddo. Individuals from both sites had evidence for the consumption of sesame. Most unexpected were proteins characteristic of soya bean and turmeric in one individual from Megiddo and banana in one from Tel Erani (Fig. 7.12) (Scott et al 2021, 5-8).

These three species are of South, East, or South-East Asian origin, and it was previously assumed that they had reached the Near East and the Eastern Mediterranean much later – with the first evidence for turmeric in the 8th c BC, banana in Graeco-Roman times, and soya bean not before the 20th c (Scott et al 2021, 7-8; https://www.soyinfocenter.com/HSS/middle_east.php). These food remains do not only provide further clear evidence that early globalisation also included the exchange of plant foods and their transport over long distances, but also serve as a cautionary tale

1 A Northern Greek feature perhaps connected to millet: Valamoti 2013, 5-6.

2 While Hruby (2008, 153) supposed them to have been used over a fire with the perforations on top filled with oil, better preserved specimens show that the perforations were on the underside and baking was done (in hot ashes?) on the burnt top side (Lis 2008, 2017a).

Fig. 7.12 Artist's impression of a Bronze Age Market in the Southern Levant (© Nikola Nevenov).

with regard to our primitivist perspective on prehistoric nutrition. Only future studies will reveal if, for example, the remains of banana can be taken as evidence for banana being transported to or even planted in the Eastern Mediterranean during the 2nd mill BC or whether seafarers involved in Indo-Mediterranean trade consumed fresh banana or dried banana chips aboard or at their destination.

7.5 Reconstruction of Bronze Age plant foods

With regard to Bronze Age plant foods, we recognise five categories. Firstly, there were staples such as cereals, pulses, olive, fig, sycamore fig, grapes, or dates, which are attested with great consistency and, given the right preservation conditions, in larger amounts in their respective distribution zones or explicitly named as such in the written evidence. Secondly, we have plant foods that were local but labour-intensive or difficult to produce, such as saffron, wine, or beer. Thirdly, there are plants which originated in different areas of the Eastern Mediterranean and spread long before the 2nd mill BC over the whole region, due to its particular interconnectedness, e.g. in Egypt pomegranate and radish of Middle Eastern origin (Murray 2000b, 625, 636) or juniper seed cones and chickpea from the Northern Levant (Serpico and White 2000b, 433; Fischer 2017a, 73). Fourthly, there is evidence for food of ultimately foreign, (South-)East Asian origin (Fig. 7.13), which had been introduced to and cultivated in the Eastern Mediterranean early in the Bronze Age, like millet and sesame, and had largely lost their exotic flair and become staple crops by the later 2nd mill BC. At this time, sesame had become the main oil plant of the Near East (Stol 2011), and millet was a summer grain e.g. in Iraq (Jakoby Laugier et al 2022).

Lastly, the 2nd mill BC also witnessed the import of exotic luxuries like pepper, cardamom, cloves, cinnamon, and vanilla (Scott et al 2021, 3, 8; Linares et al 2019) as part of trans-Eurasian and Indo-Mediterranean trade, which gained enormous momentum during this period. This corresponds with the Bronze Age translocation of foods previously observed between North Africa, Arabia, India, and Asia (Fuller et al 2011). For soya, banana, and turmeric, their status and role in the Bronze Age Eastern Mediterranean are still unclear.

Egypt is a particular case for two reasons. Firstly, there was a wealth of African plant foods such as melon, watermelon, sycamore fig, doum and argun dates, persea nuts (*Mimusops laurifolia*), and tigernut (Murray 2000b, 612-614, tab. 24.2, 24.3, 24.4; Zohary et al 2012, 5; Le Page 2019; Shahat and Jensen 2020; Eng 2020). Secondly, there is quite some evidence for aquatic plant foods. The consumption of papyrus, white and blue lotus, and water caltrop is evident (Peters-Destéract 2005, 22-26; Kappel and Loeben 2011, 64, 67), but some rarer species have potential for future research, too. Representations from Thutmosis III's mid 15th c BC "Botanical Garden" at Karnak feature both marine eelgrass (*Zostera marina*;

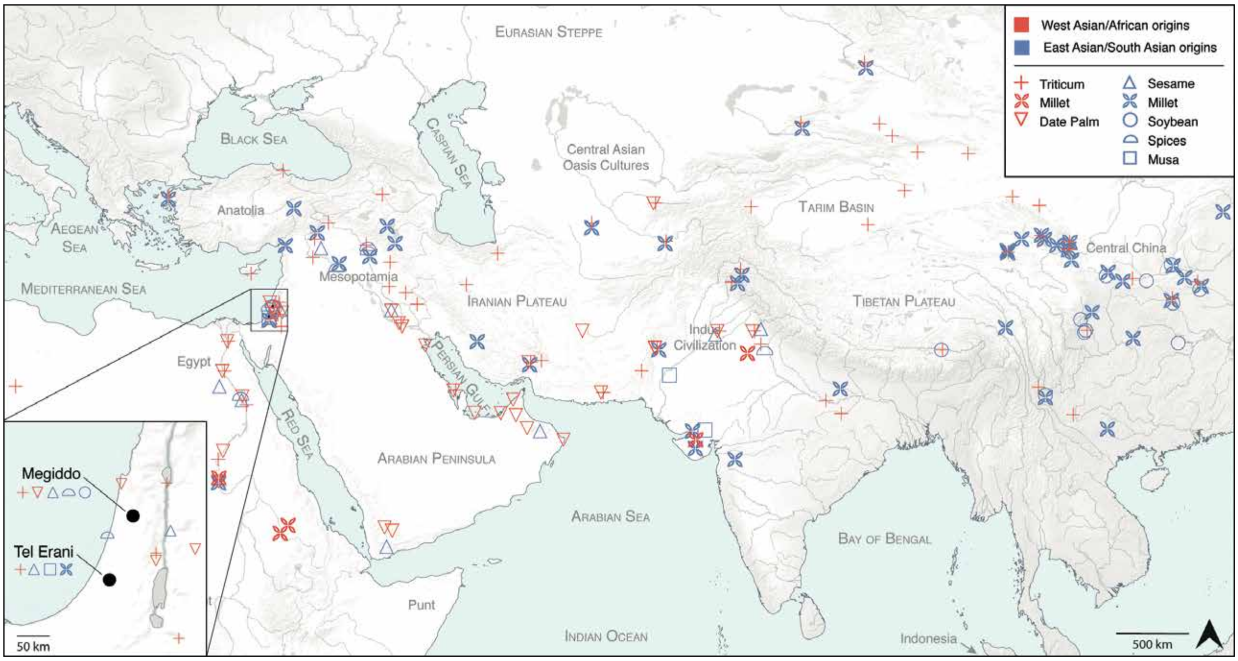

Fig. 7.13 Evidence for the spread and trade of plant foods across Asia prior to 500 BC, indicating the importance of plant foods in early globalisation processes; for details on the nature of the evidence see supplements to Scott et al 2021 (© Ashley Scott).

Beaux 1990, 119-120; also found in a late 2nd mill BC sarcophagus) and freshwater/brackwater pondweed (*Potamogeton*, possibly *lucens*, *nodosus*, or *crispus*; Keimer 1927; Beaux 1990, 184-187; Kappel and Loeben 2011, 42)[3]. Other images of *Potamogeton* exist in Theban tombs of the New Kingdom (Keimer 1927, 188-189 fig. 9, e.g. TT56 Usherhat and TT78 Horemheb). Both eelgrass and pondweed can be eaten raw or cooked as a salad, pesto, or vegetable (leaves, stems, root; cf. e.g. https://pfaf.org). The protein-rich, PUFA-rich, and gluten-free seeds of eelgrass are attested as a cereal in ethnography and recently started to be marketed as "sea rice" (Goulding 2021; Kassam 2021). In addition, *Potamogeton* has medicinal properties (Keimer 1927, 194; Beaux 1990, 186) and was an ingredient of internal and external prescriptions in Ebers Papyrus in an Upper and Lower Egyptian subspecies, as was papyrus (e.g. Eb 56: 17,14-18 antihelmintic; 669: 83,14-15 compress; Stuhr 2014, sections 2 and 30).

Whereas our ability to trace past food remains has strongly increased, the understanding of practices related to their procurement and processing is still limited. With regard to bread production, parts of an unleavened charred bread made from coarse emmer flour with many husks was preserved at Tiryns (Kroll 1982, 469). A barley flat bread was found at Hittite Kuşaklı-Sarissa in Turkey (Diffey et al 2017, 11), and breads made from wheat and leguminous flour have been discovered at Marmariani and Akrotiri in Greece (Fischer 2017a, 69). Bread/porridge-like food remains have also been found in Bronze Age northern Greece recently (Valamoti et al 2019). Since brewing was practiced in Bronze Age Greece (Valamoti 2018), it is very likely that yeast for leavened bread was available, too. The aforementioned sets of cooking dishes, soot marks, ORA, and archaeobotanical evidence indicate that stews, mashes, or soups with a combination of olive oil, cereal, legume, vegetable, and sometimes meat or seafood were popular (Tzedakis and Martlew 1999, 189; Lolos 2008, 266; Brogan et al 2013; Fischer 2017a, 90, 401). The entire Greek Bronze Age is considered "an era of boiled meals" (Megaloudi 2006, 76), with food roasting being a rather late and elitist feature (see below). In Tiryns, one cooking amphora was even found *in situ* on a LH IIIC hearth with a chopped pig jaw inside – indicating some kind of soup or stew of a vegetable base into which the marrow-rich jaw bones were placed to create a broth (Stockhammer 2008, 174; 319). In the Levant, too, stewing was the common way of cooking, with roasted foods, including meat, reserved for festivals and sacrifices (Ruiz-Gálvez and Galán 2012, 47;

3 Cf. earlier images of *Potamogeton* (possibly *crispus*) in mastabas at Saqqara in the late 3rd mill BC, e.g. Macramallah 1935, pl. V (Idout); Altenmüller 2005a, 77 fig. 1 (Nikauisesi); Altenmüller 2005b, 43 fig. 1; Peters-Destéract 2005, 90 fig. 86 (Pepyankh); Kagemni 2021, 2 (Kagemni). Pondweed seeds have recently been discovered in an early 2nd mill context at Büklükale in Turkey, too (Fairbairn et al 2019, 330).

Place	Dating	Plants	Pottery and equipment	References
Pseira, GR	1900-1700 BC		300 Eastern Cretan amphorae and jars for wine and olive oil; cooking pots, jugs, cups, fishing gear	Bass 2005, 308; Bonn-Muller 2010, 46-47
Uluburun, TR	late 14th c BC	wheat, barley, three different pulses, olives, olive oil, almond shells, pomegranates, seeds of fig, caper, and different grapes, fruit fragments of fig, terebinth resin and nuts, sumac fruits, seeds of safflower, black cumin, and coriander, acorns, pine nuts, pistachio nutlets, beer, resinated wine	ca 150 Canaanite amphorae, ca 150 Cypriot vessels (e.g. 41 white shaved juglets, 34 milk bowls, 3 bucchero jugs, 22-25 foot-ring bowls, 27 oil lamps, 10 pithoi), ca 25 Mycenaean vessels, exquisite wooden containers, straw-tip strainer, golden chalice, bronze, copper, and tin vessels (6 cauldrons, set of bowls, flask, plate, cup); coarse used oil lamps, fishing gear, charcoal from hearth/brazier	Haldane 1990, 1993; Yalçın 2005; Arnott 2008, 113
Modi, GR	late 13th to 12th c BC		>44 items: >30 large storage vessels (2 pithoi, 13 hydriai, >14 jars similar to Point Iria, 1 large relief-decorated jar), 2 small jugs, 1 kyathos, decorated skyphoi, cooking pots, 1 Ψ-figurine	Agouridis 2011; Geraga et al 2017, 1, 4
Cape Gelidonya, TR	ca 1200 BC		>20 amphorae, >2 pithoi, 6 stirrup jars, 1 white shaved juglet; cooking pot, coarse bowls, 2 lamps, some bronze spits	Bass 2005, 306; Hirschfeld 2018
Point Iria, GR	ca 1200 BC		4 Cypriot pithoi, 8 coarse stirrup jars, 3 large two-handled jars etc	Phelps et al 1999; Catsambis 2003, 4; Agouridis 2011, 31; RGZM undated

Table 7.3 2nd mill BC shipwrecks of the Eastern Mediterranean with their plant remains and pottery assemblages, both freight and board equipment.

cf. Bottéro 1987, 11-12 for Mesopotamia). It is worth noting that surprisingly similar Iron Age dishes are attested in faeces and food crusts from Central European salt mines: namely, stews of hulled barley, millet, and boiled meat, often complemented by fava bean, pea, or lentil (Barth 1999; Reschreiter and Kowarik 2008; Boenke 2020, 137-154). The Hittites, in contrast, had vocabulary, and thus probably the equipment, for (turn-)grilling and frying food, especially meat, over open fire (Kiliç et al 2017, 142). To complete a meal *comme il faut*, honey, fig, and date were sweet enough for making deserts, perhaps in combination with sesame, like in modern halva, or in mashes.

Thus, it is quite clear that the simplistic notion of a "Mediterranean triad" of bread, wine, and olive as staples does not do justice to the complexity of Aegean cuisine; rather, we find a great importance of pulses for proteins and figs as a staple and sweetener (Fischer 2017a, 396; Valamoti 2018, 2), manifold vegetables, and quite a few exotic foodstuffs. There are also regional and temporal subgroups of staples such as einkorn, millet, and linseed/camelina in Northern Greece and emmer and olive oil in Southern Greece (Kroll 1993, 496-497; Megaloudi 2006, 33).

In the Post-Palatial Period after 1200 BC, spit-roasting and sharing – presumably choice, tender – meat (and maybe vegetable food?) between peers in a kind of barbecue feast became the most prestigious mode of consumption and was later improved by adding bronze and subsequently iron firedogs (Sherrat 2004, 306, 315; Maran 2012, 125-126; on Levantine influence in this transformation process Maran 2012, 130; Ruiz-Gálvez and Galán 2012, 47; 55 fig. 8). These innovations coincided with much social unrest and competition between heads of different families for positions of power (e.g. Maran 2001; Maran 2006; Stockhammer 2011b).

7.6 Wanderers between worlds

After the spread of the Early Neolithic "crop package", the Bronze Age, and the 2nd mill BC in particular, brought about a second phase of previously unexpected and extremely long-distance mobility of plant foods. Whereas the increase in Eurasian connectivity and trade since the onset of the Bronze Age has long been accepted (e.g. Cline 1994; Matthäus 2005) and aptly termed "Bronzization" (Vandkilde 2016) in order to emphasise the importance of this early globalisation, the transport of food, and especially plant food, has hardly been taken into consideration during discussions of the dimensions and expressions of this connectedness (but see Valamoti and Jones 2010; Valamoti 2013). Now, it is clear that a large number of plant foods appeared in distant regions at much earlier dates than have often been assumed. Besides metal, precious stones, etc foods were part of long-distance exchange from the very beginning of these trade routes, and their invisibility must not be misinterpreted as insignificance. Plant foods lent themselves to serving as travelling provisions for kings, armies, ambassadors, messengers, pilgrims, colonists, seafarers, and merchants[4], since they are easily dried, transported in baskets, bags, or on strings[5], consumed (even raw), and some even proliferated by sowing at the destination. One only has to think of bread, dried fruit, dried, salted, or fermented vegetables, and nuts, and we have already proposed that

4 E.g. Brunke 2013, 339: bread, beer, oil, garlic, and onions for messengers; Michel 2013, 309, 311, 316, 318-322: cereal, oil, and instant beer for soldiers; bread, cake, beer, oil, mash, groats, sesame, chickpeas, honey, and dates for the king; cereals and meat for messengers; wine, beer, and stew for merchants.

5 E.g. strings of figs: Sallaberger 2015, 190 note 35.

banana could have played such a role for seafarers in the Indo-Mediterranean trade[6]. At the same time, these very characteristics of plant foods enabled mobility and promoted exchange between elites seeking exotic spices and requesting sophisticated cuisines but also among a broader audience like the banana-eating individual from Tel Erani, who had no particularly high status according to the archaeological context.

The variety and amounts of travelling foodstuffs, containers, and cooking equipment in the Eastern Mediterranean are amply attested by shipwrecks (Table 7.3).

These attest to the enormous amounts of plant food ingredients travelling, including some 500 kg of terebinth resin, many thousands of olive stones, and a pithos full of pomegranates found at Uluburun, the diversified contents of standardised transport containers such as Canaanite amphorae, and foreign luxury vessels for food processing, serving, and consumption made from wood, gold, bronze, copper, and tin (Yalçın 2005). Cape Gelidonya is interesting for the presence of bronze spits for the esteemed roasting of food, perhaps over a hearth or brazier, as attested at Uluburun. While the large pottery sets from Uluburun and Pseira contained and were themselves partly merchandise, the small ensembles from Modi, Cape Gelidonya, and Point Iria probably represent travel provisions and kitchen equipment for the crew, perhaps including some items for small-scale barter.

In contrast to animal-derived foodstuffs, many plant foods are easily accumulated to match the required demand and can be transported over large distances. They offer a much greater variety of beneficial micronutrients, tastes, scents, and optical pleasures of shape and colour. Therefore, they greatly enrich diets and lie at the very base of every cuisine. This is particularly true for fruit, vegetables, and spices (rather than cereals and pulses), which were held in high esteem from an early date onwards. In Mesopotamia, they were officially produced in carefully tended and watered gardens for the tables of kings and elites and for offerings to the gods, also serving as aristocratic and diplomatic gifts (e.g. Brunke 2011, 221-230; 2013; the only fruit in workmen's payment rations being dates), and they were praised in Egyptian "arboretum poems" (Schlögl 2011, 60-62 *Baumgartenlieder*). Soups served at public festivals in Bronze Age Mesopotamia contained only cereals and pulses for ordinary people, enriched by salt, meat, and one or more spices for higher ranks, but no vegetables or fruit. These, however, are listed in contexts of "upper class" delicacies, such as fish, mice, birds, and milk products or of religious offerings of butter, cheese, and honey, and there were even presents awarded for news on the availability of fruit or vegetables (Brunke 2013, 345-348). In Hittite Emar, too, "fruit and vegetables hardly belonged to the daily meal, but were met regularly only at the royal court", at public festivals, and as gifts to high dignitaries (Sallaberger 2015, 187, 190, 193). In the Aegean Linear B tablets, figs formed an important part of payment in kind for dependent workers, but there, too, they were reserved for higher staff (Fischer 2017a, 144). Since the consumption of ever-increasing amounts of food as a sign of social distinction has narrow physical limits, plant foods with their rich potential for differentiation and exotic species offered themselves to complex societies as ways to express status and participation vs exclusion. Last but not least, we may assume that, similar to the import and representation of exotic plants and animals by the Egyptians, which supposedly expressed appropriation and engulfment of foreign parts of the world and thus a symbolic widening of imperial borders (Beaux 1990, 316; Widmaier 2009, 78), eating peregrine foodstuffs may also have symbolised an aspiration to ruling their distant locations of origin.

7.7 Results and outlook

While the importance of plant food for past human nutrition has long been accepted, primitivist perspectives on prehistoric culinary practices are still lingering. Thanks to novel scientific approaches to food remains in vessels and dental calculus, it has recently become feasible to unravel the complexity of Bronze Age cuisines in the Eastern Mediterranean in general, beyond local evidence in Egypt, the Hittite Empire, and Mesopotamia, where textual and pictorial sources have long indicated the importance of elaborate foodways. Now, we have the chance to dramatically enlarge our previous dataset and, in particular, link information on species and cooking practices with human individuals. This has become possible by tracing individual dietary practices by extracting food residues (lipids, proteins, microremains, and perhaps one day also ancient food DNA) from human dental calculus – thereby approaching the individual and moving far beyond a general and rather structural assessment of prehistoric diets.

For a long time, the complexity of Bronze Age plant foods has suffered from the limited preservation of many of its ingredients, with those parts that add taste and sophistication to food being, unfortunately, the most difficult to trace: namely, fresh and dried spices, fruits, and vegetables. Moreover, in spite of being aware of the intensity of trans-Eurasian interconnectedness since at least the Bronze Age, plant foods have hardly been considered relevant to these exchange systems. We want to emphasise the importance of plant foods in these early networks – as

6 The same is obviously true for dried, smoked, or salted meat (Michel 2013, 321-322) or fish and preserves of pemmican-style, but these may not have been accessible to everyone, and food poisoning from rotted meat might have been a threat.

luxury goods for elites and their specialised cooks, as well as easily stored food for voyages across oceans and continents. High-quality meat has long been recognised as an indicator for elite diet. However, plant foods added elaboration, as their variety allowed the development of cuisines on different levels (geographic, status-, age- or gender-related, etc), thereby expressing and reinforcing social belonging.

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Plant list

acorn see oak
almond – *Prunus amygdalus/dulcis* and *Amygdalus communis/dulcis*
aniseed – *Pimpinella anisum*
annual mercury – *Mercurialis annua*
apple – *Malus domestica*
apricot – *Prunus armeniaca*
argun palm – *Medemia argun*
Arundo sp.
asafoetida – *Ferula* sp.
asphodel – *Asphodelus sp.*
Assyrian plum – *Cordia myxa*
Atlantic pistachio – *Pistacia atlantica*
aubergine – *Solanum melongena*
babe's breath – *Gypsophila* sp.
balanites see desert date
banana – *Musa* sp.
barley – *Hordeum vulgare*
bay laurel – *Laurus nobilis*
bedstraw – *Galium* sp.
beet – *Beta* sp.
Bellevalia sp.
bindweed – *Convolvulus* sp.
birdweed – *Polygonum aviculare*
bitter cucumber – *Citrullus colocynthis*
bitter onion – unclear, mentioned in Hittite texts (Hoffner 1974, 109)
bitter vetch – *Vicia ervilia*
black cumin – *Nigella sativa*
black mustard – *Brassica nigra*
black nightshade – *Solanum nigrum*
blackberry – *Rubus fruticosus*
borage – *Borago* sp.
bread wheat – *Triticum aestivum*
bromes – *Bromus* sp.
broomcorn millet – *Panicum miliaceum*
buckwheat – *Fagopyrum esculentum*
bugleweed – *Ajuga* sp.
burnet – *Sanguisorba* sp.
cabbage – *Brassica* sp.
calamus – *Acorus calamus*
camomile – *Matricaria* sp.
campion – *Silene* sp.
canary grass – *Phalaris* sp.
cannabis see hemp
caper – *Capparis spinosa*
cardamom – *Elettaria cardamomum* and *Amomum repens*
carob – *Ceratonia siliqua*
carrot – *Daucus carota*
cassia – *Cinnamomum cassia*
cedar – *Cedrus* sp.
celery – *Apium graveolens*
centaury – *Centaurea* sp.
chestnut – *Castanea sativa*
chickpea – *Cicer arietinum*
chicory – *Cichorium endivia*
Christ's thorn jujube – *Ziziphus spina-christi*
Chrysanthemum sp., see also crown daisy
cinnamon – *Cinnamomum verum*
Cistus sp.
cleavers – *Galium aparine*
clover – *Trifolium* sp.
club wheat – *Triticum compactum*
clustered dock – *Rumex conglomeratus*
common knotweed – *Polygonum arenastrum*
common poppy – *Papaver rhoeas*
coriander – *Coriandrum sativum*
Cornelian cherry – *Cornus mas*
corn cleavers – *Galium tricornutum*
corn spurry – *Spergula arvensis*
cornsalad – *Valerianella* sp. and *Valerianella muricata*
cotton thistle – *Onopordum* sp. and *Acanthium* sp.
cowherb – *Vaccaria hispanica*
cowpea – *Vigna* sp.
crabapple – *Malus sylvestris*
crabgrass see finger millet
cranesbill – *Geranium* sp.
cream pea see Cyprus vetch
cress – *Lepidium sativum*
crown daisy – *Chrysanthemum coronarium* and *Glebionis coronaria*

cucumber – *Cucumis sativus*
cumin – *Cuminum cyminum*
Cyperus sp.
Cyprus vetch – *Lathyrus ochrus*
date palm – *Phoenix dactylifera*
desert date – *Balanites aegyptiaca*
devil's thorn – *Emex spinosa*
dill – *Anethum graveolens*
dog's tooth grass – *Cynodon dactylon*
doum palm – *Hyphaene thebaica*
dragon arum – *Dracunculus vulgaris*
dragon's head – *Lallemantia* sp.
durum wheat – *Triticum durum*
dwarf elder – *Sambucus ebulus*
Echium sp.
eelgrass – *Zostera marina*
Egyptian acacia – *Vachellia nilotica*
einkorn – *Triticum monococcum*
elder – *Sambucus nigra*
Eminium spiculatum
emmer – *Triticum dicoccum*
Erucaria microcarpa
European hackberry – *Celtis australis*
European heliotrope – *Heliotropium europaeum*
false cleavers – *Galium spurium*
false fennel – *Ridolfia segetum*
fava bean – *Vicia faba*
fennel – *Foeniculum vulgare*
fenugreek – *Trigonella foenum-graecum*
fiddle dock – *Rumex pulcher*
field bindweed – *Convolvulus arvensis*
field gromwell – *Lithospermum arvense* and *Buglossoides arvensis*
fig – *Ficus carica*
finger millet – *Digitaria* sp.
flax – *Linum usitatissimum*
foxtail millet – *Setaria italica*
frankincense – *Boswellia* sp.
fumewort – *Fumaria* sp.
garden vetch – *Vicia sativa*
garlic – *Allium sativum*
germander – *Teucrium* sp.
gold of pleasure – *Camelina sativa*
goosefoot – *Chenopodium album*
gourd – *Lagenaria siceraria*
grape – *Vitis vinifera*
grass pea – *Lathyrus sativus*
great willowherb – *Epilobium hirsutum*
Gundelia thistle – *Gundelia tournefortii*
hairy cowpea – *Vigna luteola*
hare's ear – *Bupleurum* sp.
hare's-foot clover – *Trifolium arvense*
harmal – *Peganum harmala*
hawthorn – *Crataegus* sp.
hazelnut – *Corylus avellana*
hemp – *Cannabis sativa*
henbane – *Hyoscyamus* sp.
henna tree – *Lawsonia inermis*
heron's bill – *Erodium* sp.
hill mustard – *Bunias orientalis*
honeysuckle – *Lonicera* sp.
horned poppy – *Glaucium* sp.
Indian sage – *Salvia indica*
iris – *Iris* sub. *Iris*
ivy – *Hedera* sp.
ivy-leafed speedwell – *Veronica hederifolia*
jasmine – *Jasminum officinale*
Jerusalem thorn – *Paliurus spina-christi*
juniper – *Juniperus* sp., especially *J. phoenicea*
knotweed – *Polygonum* sp.
kurrat – *Allium ampeloprasum*
Lathyrus sp.
lavender – *Lavandula* sp.
leek – *Allium porrum*
lemon balm – *Melissa officinalis*
lentil – *Lens culinaris*
lettuce – *Latuca sativa*
lime – *Tilia* sp.
linseed see flax
liquorice – *Glycyrrhiza glabra*
little mallow – *Malva parviflora*
little sparrow-wort – *Thymelaea passerina*
lotus – *Nymphaea lotus* (white lotus) and *Nymphaea caerulea* (blue lotus)
lucerne – *Medicago sativa*
lupin – *Lupinus* sp.
mallow – *Malva* sp.
mandrake – *Mandragora* sp.
marigold – *Calendula* sp.
marsh-bedstraw – *Galium palustre*
Mary thistle – *Silybum marianum*
medlar – *Mespilus germanica*
melon – *Cucumis melo*
milkvetch – *Astragalus* sp.
mimusops see persea
mint – *Mentha* sp.
monk's pepper – *Vitex agnus-castus*
moringa – *Moringa oleifera*
mullein – *Verbascum* sp.
mustards see black mustard, hill mustard, white mustard
myrrh – *Commiphora* sp.
myrtle – *Myrtus communis*
nabq see Christ's thorn jujube
nailwort – *Paronychia* sp.
Narbonne star-of-Bethlehem – *Ornithogalum narbonense*
narrowleaf plantain – *Plantago lanceolata*
nettles – *Urtica* sp. (stinging) or *Lamium* sp. (dead)
nettle-leaved goosefoot – *Chenopodiastrum murale*

nightshades see black nightshade, red nightshade
nutmeg – *Myristica fragrans*
oak – *Quercus* sp.
oats – *Avena* sp.
okra – *Abelmoschus esculentus*
olive – *Olea europaea*
onion – *Allium cepa*
Onosma sp.
opium poppy – *Papaver somniferum*
orache – *Atriplex* sp.
Oriental hackberry – *Celtis tournefortii*
papyrus – *Cyperus papyrus*
parsley – *Petroselinum crispum*
parsnip – *Pastinaca sativa*
pea – *pisum sativum*
pear – *Pyrus amygdaliformis*
pennyroyal – *Mentha pulegium*
pepper – *Piper nigrum*
persea – *Mimusops laurifolia*
pheasant's eye – *Adonis* sp.
pine – *Pinus* sp.
pink – *Dianthus* sp.
pistachio – *Pistacia vera*
plantains – *Plantago* sp.
plum – *Prunus domestica*
poison darnel – *Lolium temulentum*
poison gooseberry – *Withania somnifera*
Polish millet – *Digitaria sanguinalis*
pomegranate – *Punica granatum*
pondweed – *Potamogeton* sp.
poppy see common poppy, horned poppy, opium poppy
prickly juniper – *Juniperus oxycedrus*
prickly scorpion's-tail – *Scorpiurus muricatus*
primrose – *Primula* sp.
purslane – *Portulaca oleracea*
quince – *Cydonia vulgaris/oblonga*
radish – *Raphanus raphanistrum* subsp. *sativus*
raspberry – *Rubus idaeus*
red nightshade – *Solanum villosum*
red pea – *Lathyrus cicera*
reseda – *Reseda* sp.
ribwort – *Plantago* sp.
ricinus – *Ricinus communis*
rice – *Oryza sativa*
rose – *Rosa* sp.
rue – *Ruta graveolens*
rye – *Secale cereale*
safflower – *Carthamus tinctorius*
saffron crocus – *Crocus sativus*
sage – *Salvia officinalis*
sandspurry – *Spergularia* sp.
scarlet pimpernel – *Anagallis arvensis*
seepweed – *Suaeda* sp.
senna – *Senna alexandrina*
sesame – *Sesamum indicum*
shaggy sparrow-wort – *Thymelaea hirsuta*
sloe – *Prunus spinosa*
snot berry – *Cordia ovalis*
soapnut – *Sapindus* sp.
sorghum – *Sorghum* sp.
sorrel – *Rumex* sp.
soya bean – *Glycine* sp.
Spanish vetchling – *Lathyrus clymenum*
sparrow-wort – *Thymelaea* sp.
speedwell – *Veronica* sp.
spelt – *Triticum spelta*
sponge gourd – *Luffa aegyptiaca/cylindrica*
spring onion – *Allium* sp.
spurge – *Euphorbia* sp.
St. John's wort – *Hypericum* sp.
strawberry – *Fragaria vesca*
strychnine tree – *Strychnos nux-vomica*
storax – *Styrax officinalis*
sumac – *Rhus coriaria*
summer savory – *Satureja hortensis*
sun spurge – *Euphorbia helioscopia*
sweet clover – *Melilotus* sp.
sword-leaf dogbane – *Trachomitum venetum*
sycamore fig – *Ficus sycomorus*
Syrian mesquite – *Prosopis farcta*
tamarisk – *Tamarix* sp.
taro – *Colocasia esculenta*
terebinth – *Pistacia terebinthus*
thyme – *Thymus* sp.
tigernut – *Cyperus esculentus*
Timopheev's wheat – *Triticum timopheevii*
true camomile – *Matricaria chamomilla*
true sedges – *Carex* sp.
turmeric – *Curcuma longa*
valerian – *Valeriana officinalis*
vanilla – *Vanilla* sp.
vervain – *Verbena officinalis*
violet – *Viola* sp.
walnut – *Juglans regia*
water caltrop – *Trapa natans*
watercress – *Nasturtium officinale*
watermelon – *Citrullus lanatus*
water plantain – *Alisma plantago*
white mustard – *Sinapis alba*
wild grape – *Vitis sylvestris*
wild barley – *Hordeum spontaneum*
wild buckwheat – *Polygonum/Fallopia/Bilderdykia convolvulus*
wild foxtail millet – *Setaria viridis*
wild ginger – *Siphonochilus aethiopicus*
wild leek see kurrat
wild pea – *Pisum elatius*
wild pear – *Pyrus* sp.

wild oats – *Avena barbata*
wild radish – *Raphanus raphanistrum*
wild sawa millet – *Echinochloa colona*
wild teff – *Eragrostis pilosa*
willow – *Salix* sp.
wormwood – *Artemisia* sp.

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Chapter 8

The importance of flavoured food: a (cautious) consideration of spices and herbs in Indus Civilization (ca 3200-1500 BC) recipes

Jennifer Bates

Abstract
Diversity in plant foods was a critical part of Indus Civilization (South Asia ca 3200-1500 BC) economies. This belies a diversity in Indus foods and foodways. Recent research has shown that the bland staple cereal and pulse base would have been expanded by a range of flavours, from spices to sweeteners and beyond. While the diversity of possible plant oilseeds, herbs, spices and fruits have been explored in numerous other papers, how these might be combined is a new area of research, with new methods like starch and residue analysis beginning to provide new insights. This paper outlines how we are now in a position to start thinking about what an Indus sense of "flavour" might have been, and how this might have been variable across the vast civilization, and what additional data we need to further this new aspect of Indus archaeobotany.

Keywords: *South Asia, Indus Civilization, flavour, identity*

8.1 Introduction

Eating is a necessity for all human beings at a biological level, but it is also inextricably woven into a range of thought processes, social decisions and choices (e.g. Appadurai 1981; Dietler 1996; Douglas 1972; Fischler 1988; Goody 1982; Hastorf 2016; Messer 1984; Smith 2006; Twiss 2012). Sherratt (1991, 50) observed that "we do not eat species, we eat meals". Food is how we combine the basic ingredients, the plant and animal matter, to make something that we want to put in our bodies. Levi Strauss (1968) famously described it as something we must decide is not only good to eat but good to think as well. And in this respect, our categorizations of good to eat (see Hastorf 2016, 2) inevitably include does it taste right?

Flavour, the way something tastes, is a critical component of making something not just good to eat but good to think. Flavour is deeply embedded in the social construction of food. Hastorf (2016) and Rowan (2020) have noted that today we associate specific flavors with specific dishes, cuisines and cultures, building on (Rozin 1982, 1973) flavour principles. We see this stretching back into antiquity (Hamilakis 2013; Rowan 2020), for example with the specific instructions given by Han Dynasty nobility regarding the way certain foods should be prepared and flavoured for inclusion in the tomb of Lady Di: salt, sugar, honey, soy sauce and shih (salted darkened beans), used to make keng stews of

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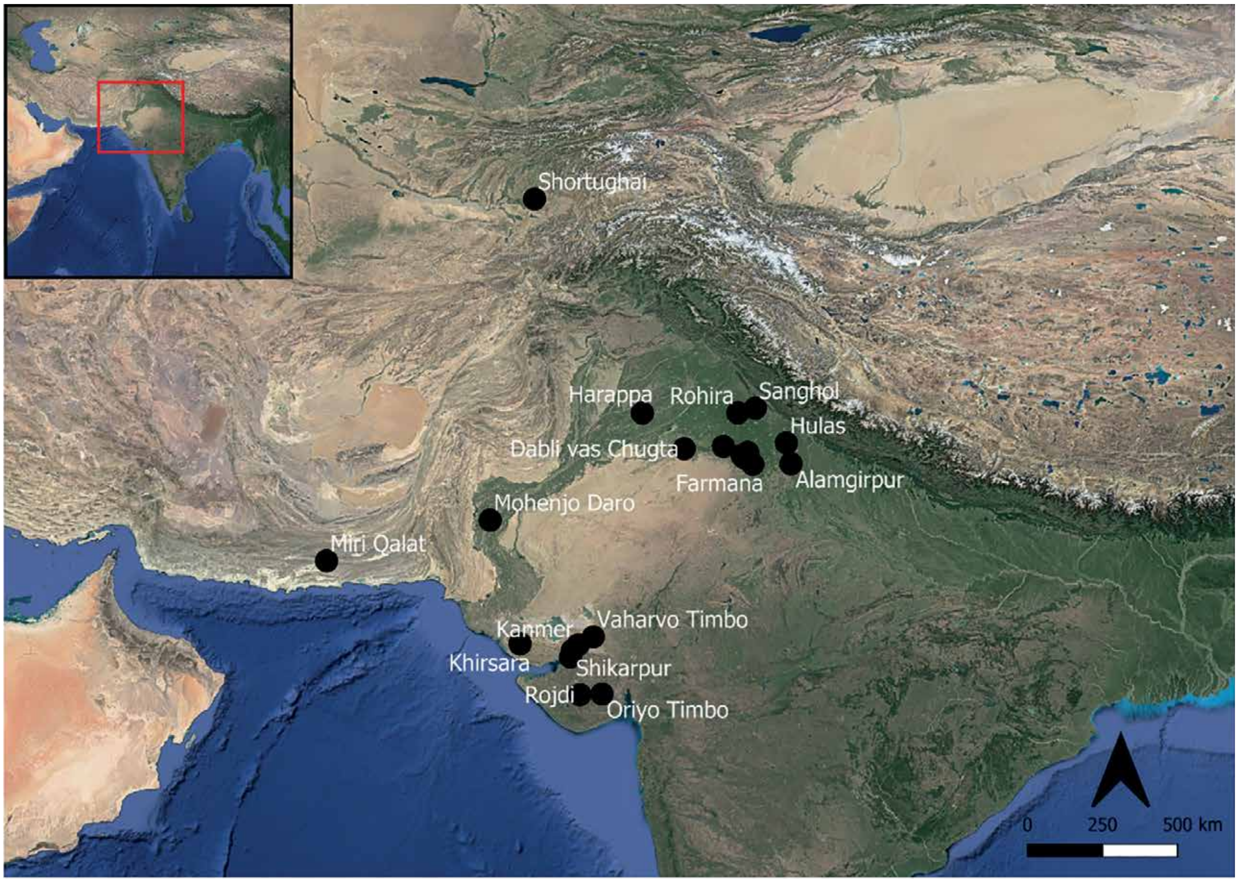

Fig. 8.1 Map of the Indus Civilization showing the location of the sites discussed in this paper.

seasoned boiled grains and vegetables (Ying-Shih Yü 1977). Flavours are embedded in food-based social practice, and food-based social practice is embedded in flavour (see Rowan 2020).

In this paper a short thought experiment is laid out in which I ask how far can we push our thinking about food archaeologically? Can we consider the emic choices about flavours and the right combinations of flavours to make "good" food in archaeological contexts where we don't have texts? The Indus Civilization of South Asia (ca 3200-1500 BC) is the setting for this thought experiment. A great deal is now known about Indus agriculture (e.g. Bates 2020, 2019a, 2019b; Fuller 2002; Kajale 1991; Petrie and Bates 2017; Pokharia et al 2014; Pokharia and Srivastava 2013; Weber 2003, 1992), and work is now moving beyond this to think about how agricultural products were incorporated into Indus notions of food. Covering up to a possible million square kilometers the Indus (Fig. 8.1) incorporated a diversity of lifeways and social structures within its umbrella (Kenoyer 1998; Parikh and Petrie 2019; Petrie 2013; Possehl 2002), and this is beginning to reflect not only in the agricultural systems deployed (Petrie et al 2017; Petrie and Bates 2017; Pokharia et al 2017; Weber et al 2010a), but perhaps too in food (Bates et al 2018; Bates 2019b, 2020; Chakraborty et al 2020; Chase 2010, 2012a, 2012b; Kashyap and Weber 2010, 2013, 2016; Suryanarayan et al 2021; Weber et al 2010b) urban and post-urban phase populations of the Indus Civilisation (3200-1500 BCE. Through reviewing the kinds of foods that have been identified this paper will briefly consider this then turn to how far we can push the notion of "flavour" within Indus notions of food and how this might reflect emic notions of diverse tastes.

8.2 Creating food: theories of flavour

Flavour is a chemical reaction in the mouth between the substance -food and its ingredients – and receptors in our taste buds. Other factors like smell, texture, temperature affect flavour and the experience of flavour, making it a complex dance between numerous elements, senses and organs (Trivedi 2012).

Five flavours are generally recognized as "pure" as they cannot be separated from the sensation accompanied by tissue damage (Ikeda 2002). Sweetness is the sugar content of a food, sometimes described as a richness in taste. Sourness is the acidity. Bitterness on the other hand is the tannin content, a sharpness. Saltiness is the sodium or alkaline ion content, while the fifth is umami or savoriness.

However, these five are by no means universally alone, and while these are recognized from studies on taste receptors in the mouth (see Ikeda 2002), there are others discussed in popular food culture and within food science. Pungency (spiciness), coolness, numbness, a metallic taste, astringency, fattiness, alkalinity for example are all possible flavours (see for example Keast and Costanzo 2015).

Beyond the types of taste, how we experience them is culturally specific. Hastorf (2016), Hamilakis (2013) and Rowna (2020) have demonstrated the importance of sensory aspects relating to food and how senses are infused with cultural understandings of food. While flavours are something measurable to a degree – things have a spice-level, a sweetness etc – they are not experienced the same by all people. We perceive food within a culturally defined world of food (Levi-Strauss 1968) and flavour is a critical part of this. While something might be seen as sweet or spicy, how spicy we perceive it to be, or how sweet a food should be made, are very much a part of this food-framework. For example, Boseland (Greenaway 2013) has suggested that there are cultural chilis preferences today, with some Asian cultures preferring sharp fast heat chilis to those in North America where flat sustained heat is preferred. The combination of flavor is also framed within our foodways – the combination of jam and Yorkshire pudding – a sweet dessert with a savoury main – is something that would seem anathema to a southern British person, but as a standard starter dish for a northerner. In the south UK cold milk on cereal for breakfast is standard, changing the experience of the food through temperature, and making it a strange dish for a northerner used to warm milk.

However, such knowledge is an emic experience. Food is embedded in our lives, flavour infused within this cultural realm, and it is only through my own experiences living in a household with northern and southern UK parents that I straddle these foodways. When thinking to the past and our archaeological data we face two challenges: the loss of the emic knowledge associated with food, and the desire to find shortcuts to circumvent this loss. Texts describing the intricacies of food choices, recipes and the ideas behind flavour combinations, such as that in the tomb of Lady Di (Ying-Shih Yü 1977) and in the Roman and Aegean (Hamilakis 2000; Rowan 2020), are one route towards this more personal or intimate sense of taste choices. But when no texts are available, we are left with a gap in the record, where we see a range of possibilities with no subtext as to their meaning.

When it comes to flavour this is the conundrum we face, particularly with non-textual past cultures, or contexts where the foodways and choices were not explicitly discussed in texts: how do we move from our patchy records to thinking about something so emically internalized? I suggest that we need to look to how our seeds were being used across the entire cultural assemblage, how different elements of this were being used in combination (the assemblage patterns we are seeing repeated over and over), and then to other disciplines, those that can support our work and perhaps push it further. When combined this might allow us to see bigger pictures, and start to get an idea of the wider image of the kinds of choices people were making with regard to food and flavours and how these should be combined, allowing the patterns emerging from the bigger datasets.

8.3 Building from the (cereal/pulse) base: mixing food and identity

8.3.1 Preservation challenges

The predominant set of plant remains in Indus archaeobotany are macrobotanical remains, and of those, charred materials form the largest, if not only dataset of seeds (see Bates 2019a for compilation). A few examples of fibres (charred, impressions and mineralized inside a bead), cloth fragments, and impressions of seeds exist, but these are extremely rare finds. One result of this is that there is a likely discrepancy in what types of plants we find preserved. Cereals are more likely to reach fire than fruits for example, larger robust elements are more likely to survive charring, and things that are whole are likely to have more identifiable features than those that have been transformed before reaching fire (see discussions in Fuller et al 2014; Reddy 2003 for example). One side of effect of this then is it is not surprising perhaps that the Indus has traditionally been seen as a cereal-based economy. However, these cereals are large starchy grains, and form the basis of many farming civilizations globally across time, regardless preservation, and as such it is not a stretch to argue that charring that has led to this cereal-based dominance but the likelihood that the Indus was indeed based on cereals.

In his seminal work, Weber (1999, fig. 4) noted that there was a basic tiering to the archaeobotanical finds at sites, with the "most abundant species recovered and those most crucial to the subsistence system" (Weber 1999, fig. 4) being the cereals. At Harappa these were wheat and barley, at Rojdi these were millets. The argument boiled down to: regardless the region some kind of cereal dominated. This has held true – Kanmer (Pokharia et al 2011), Khirsara (Pokharia et al 2017), Masudpur I, Masupdur VII, Dabli vas Chugta (Petrie and Bates 2017), Oriyo Timbo (Reddy 2003) and so on (see Bates 2019a for summary data) show some kind of cereal, be it wheat, barley, rice or millets, dominating the assemblage. Secondary to the cereals are "cultivated crops of lesser importance" (Weber 1999, fig. 4), including pulses, oilseeds and few fruits. And finally

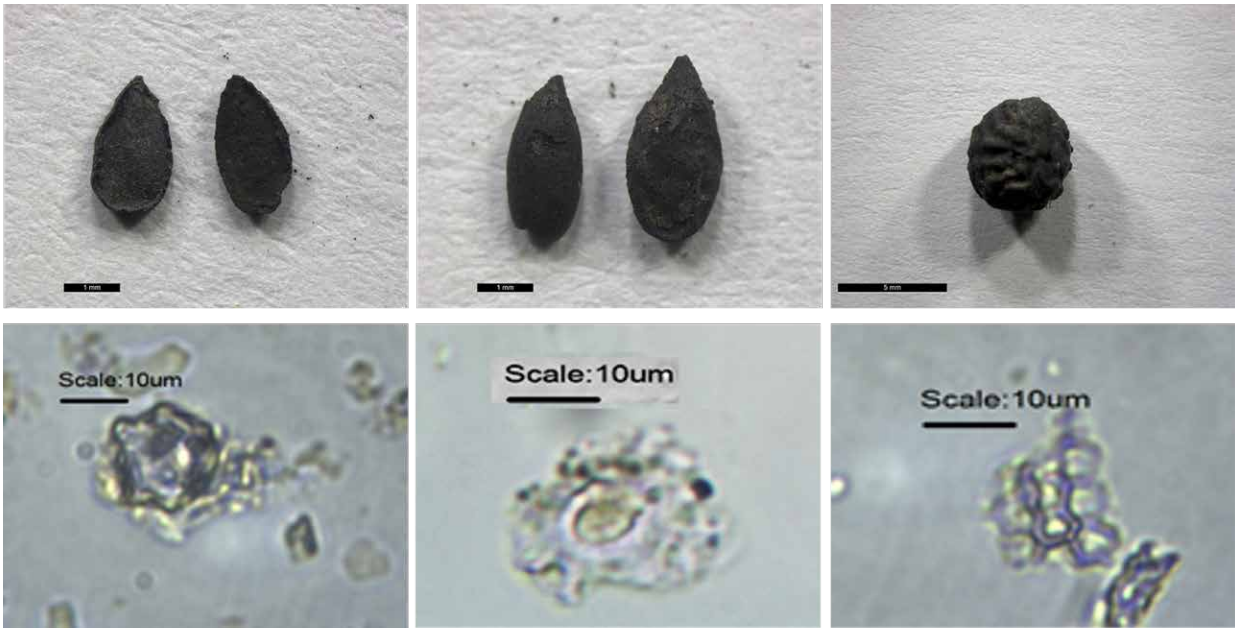

Fig. 8.2 Examples of Tier III crops from sites in the northeast of the Indus. Top left: sesame; middle: flax; right: jujube. Bottom left: date palm; middle: *Musa* sp.; right: fruit rind. From the Land, Water, Settlement sites (Bates 2016).

found at almost all sites but in small amounts are “a mix of cultivated and wild species that play a minor role in subsistence” (Weber 1999, fig. 4), Tier III plants.

More importantly, a recognition that there is a bias in preservation requires us to recognize that there may be missing elements in our datasets, that while cereals were the likely staples of the Indus, there maybe challenges that face us in understanding the less commonly found elements of our charred datasets, those things that had less chances of reaching fire and being preserved, and turn up only occasionally at our sites, or in small numbers. These are the Tier III plants Weber (1999) is referring to.

It should perhaps be first noted that the division of these plants into categories – fruits, oilseeds, nuts, spices and so on – is entirely arbitrary and determined by our own emic sense of what these things are and how they should be used. Weber (1989, 265) brings this home by describing the ways jujube, the ubiquitous “fruit” in South Asian prehistory, is used today, from eating it raw as a fruit snack, to making it into tea, using it as a fodder, using the bark for tanning and medicine, and using the wood as building material. Oilseeds similarly demonstrate the discomfort with this categorization of plants into simple groups; *Linum usitatissimum* (linseed/flax) can be an oilseed, a fiber crop and potentially a fodder. It is discussed as such in the literature: at Miri Qalat linseed is discussed as a fibre (Tengberg 1999, 8) while at Kanmer (Pokharia et al 2011, 1844) and Masudpur I (Bates 2016; Petrie and Bates 2017) it is explored as oilseed. As I note in a previous paper on the danger of assuming a function to any of these Tier III plants at Indus sites (Bates 2019b), we need to think more on the pathways of use and preservation at our sites.

In this previous paper (Bates 2019b) I warned about the dangers of the utilitarian fallacy – of stretching our assumptions on the role of plants in the archaeological record (see also Fuller 2002; Fuller et al 2014; Fuller and Madella 2002). The utilitarian fallacy is the notion that all seeds on site must have a function, for example as famine food, medicine or fodder (Fuller and Madella 2002; Fuller 2002; Dennell 1976; Hamilakis 2000), without consideration of taphonomy, preservation pathways or context, and with an over-reliance on the “functionality” of said plants. In particular this relates to their ethnobotanical or ethnohistoric “functionality”, stretching it automatically back to the past. We see this for example with species like *Cannabis sativa, Ephedra* sp. and *Datura stramonium* found at the Indus site of Kunal (Saraswat and Pokharia 2003, 133), where based on much later texts, religious practices and non-Indus references they are interpreted as possible Indus stimulants and medicinal plants despite turning up in extremely small numbers (1-2 seeds in total) in fill contexts. This is not to say they were not acting as such at Indus sites, we just need other additional information such as assemblage, context and consideration of pathways like weed ecologies, crop processing and fuel first.

Despite this, we can start to think about how Indus people might have thought about and used these “non-staple” plants within this their cuisines. One initial step is to look at how they are distributed across the Indus, and how they were being used in different regions to see if there are patterns that can be drawn out.

8.3.2 Non-staple plants at Indus sites

The Tier III plants have proved challenging for analysis and discussion. As they are a minor component of the assemblages but consistently found at sites they have lent themselves either to being ignored, dropped in to tables and then forgotten, or to being over-interpreted as critical components of medicines or ritual practices, despite their low quantities or obscure taphonomic information (Bates 2019b). However, these potentially edible plants are found at all sites with flotation (Weber 1999; Bates 2019a, 2019b), and do require cautious discussion, recognizing concerns relating to utilitarian fallacies. As Weber himself noted in many works (e.g. Weber 2003, 1999, 1997; Weber et al 2010b), these "Tier III" plants though small in quantity but might have altered the way in which the cereals and pulses, those bulk foods, would have been experienced. Microbotanical data adds to this with phytolith and starch data showing other "missing crops" that would be taphonomically invisible otherwise (Bates 2019b, 2016; Bates and Petrie 2016; García-Granero et al 2017b, 2017a, 2016, 2015; Kashyap and Weber 2010; Madella, 2003, 1997; Weber et al 2011) (Fig. 8.2).

One thing that can be noted is that while Tier I crops are regionally defined, with wheat and barley the main crops in Punjab and Sindh, millets in Gujarat and a mix of millets, rice and some wheat/barley in the northeast (see Petrie and Bates 2017; Weber et al 2010a), the Tier III plants are highly diverse across the Indus Civilization (Bates 2019a, 2019b). There are nuts like *Juglans regia* (walnuts) and *Prunus dulcis* (almonds) at Hulas (Saraswat 1993), and *Pistacia vera* (pistachio) at Shortughai (Willcox 1991). Fruits have been found at most sites, from the *Ziziphus* sp. (jujube) found ubiquitously at sub-continential prehistoric sites, to berries like *Phyllanthus* sp. (emblic) at Banawali (Lone et al 1987) and Kunal (Saraswat and Pokharia 2003), stone fruit like *Elaeagnus angustifolia* (Russian olive) at Shortughai (Willcox 1991) and a range of others like *Citrus limon* (lemon) at Sanghol (Saraswat 1997), *Phoenix dactylifera* (date) at Miri Qalat (Tengberg 1999), and wild and domestic taxa within Vitaceae (see debate in (Bates 2021a). Oilseeds are also common, from the mustards that still require more species level identification refinement but could include *Brassica juncea* (brown mustard) at sites like Banawali (IAR 1994-5; Saraswat et al 2000), and linseed or flax (see fiber debate in Bates 2021b) and sesame both wild (*Sesamum malabaracum*) at Varharvo Timbo (García-Granero et al 2016) and domesticated (*Sesamum indicum*) at numerous sites. A whole range of "spices" and "herbs" (to use Weber et al 2011's terminology) can also be seen, from *Zingiber* sp. and *Curcuma* sp. being combined at Farmana (Weber et al 2011), the presence of *Trigonella foenum-graceum* (fenugreek) at Rohira (Saraswat 1986), Kunal (Saraswat and Pokharia 2003) and Banawali (Saraswat et al 2000), and even whole *Allium sativum* (garlic) cloves at Balu and Farmana (Saraswat and Pokharia 2002; Weber et al 2011) (See table 1 and Bates 2019a, 2019b).

This diversity is striking, and only scratches the surface – looking to the database of recovered archaeobotanical remains (Bates 2019b), it can be seen that there are far more than listed here (for example melons like muskmelon (*Cucumis melo*) and microbotanical remains found by scholars like García-Granero et al (2015) and Kashyap and Weber (2013) that expand this. We can therefore begin to ask would Indus people have seen these as having distinct types of flavours and created distinct flavour profiles using them? What types of sense would the different taxa have evoked to an Indus person and led them to combine these flavours – what would they have been understood as the right kinds of flavours to mix?

8.3.3 Non-charred approaches

As the archaeobotanical datasets continue to expand we are faced more and more with the diversity of our assemblages and we do need to think about ways to handle this, and to think beyond just taxa lists. Foodways theory is moving into Indus archaeology and providing new avenues to help us with this, and new methods are aligning with the diversity in our macrobotanical datasets that are giving us new insights and aiding us in interpreting the complexities of Tier III plant use and Indus food and flavours.

Biochemical approaches are a newly emerging way to explore aromatics and flavour profiles (e.g. Martins et al 2012). We are seeing such approaches emerging in archaeology as residue analysis and DNA for example expand, with McGovern (1996) for example using an organic compound residue approach to wine jars at Hajji Firuz to show the use of terebinth resin as a preservative, while DNA analysis by Hansson and Foley (2008) showed the presence of olive (*Olea europaea*), oregano (*Origanum vulgare*), and *Pistacia* sp. in amphoras from Chicos.

While residue and DNA analysis from Indus sites has not yet been taken this far, the cutting-edge residue analysis work by Chakraborty et al (2020) and Suryanarayan et al (2021) has sought to explore exactly what was being put into and cooked in Indus vessels. In both cases animal products overwhelmed the results, specifically degraded non-ruminant animal fats. There are myriad possible reasons for this, including taphonomy and the limits of the analytical approaches, and it does not preclude the cooking of plant matter (Suryanarayan et al 2021). Most interestingly there are key differences between Gujarat and the east. Chakraborty et al (2020) report dairying as one of the finds from their analysis of samples from Gujarat. Suryanarayan et al (2021) however found that dairying was limited in the samples from the east – only four out of the 172 fragments analysed showed a possible dairying signature. And Suryanarayan et al (2021) report variability between sites in terms of their residue results.

Latin binomial	Common name	Edible elements	Other possible uses
Allium sativum	Garlic	Cloves	Medicinal
Areca sp.	Areca nut palm	Nut	Stimulant, palm fibre
Arecaceae	Palm	Nuts and fruits (species dependant)	Stimulants, palm fibre, wood
Artemisia sp.	Mugworts and wormwoods	Leaves	Insect repellant, alcohol, weed
Brassica sp.	Cruciferous plants	Oilseeds, leaves (species dependent)	Weed, fodder
Brassica juncea	Brown mustard	Oilseed, leaves	Weed, fodder
Capparis aphylla (Capparis decidua)	Karira	Fruit	Stimulant, marginal land weed
Cannabis sativa	Cannabis	Seed	Stimulant, ritual, weed
Carissa carandas	Bengal currant	Fruit	Medicine
Cucumis sp.	Melons and cucumbers	Fruit	
Cucumis melo	Muskmelon	Fruit	
Curcuma sp.	Tumeric	Rhizome	Medicine, dye, ritual
Citrus limon	Lemon	Fruit, peel	Medicine
Citrullus cf. *colocynthis*	Bitter gourd	Fruit	Medicine, weed
Citrullus lanatus	Watermelon	Fruit, seeds	
Coccinia cf. *grandis*	Ivy gourd	Fruit	Medicine, weed
Corchorus sp.	Mallows and jutes	Leaves, seeds (species dependent)	Fibre
Coriandrum sativum	Coriander	Leaves, oilseed, root	
Cordia sp.	Manjack	Fruit (species dependent)	Glue, wood, stimulant, fodder, medicinal
Cordia rotthii (Cordia dichotoma)	Indian cherry	Fruit	Fodder, medicinal
Dioscorea sp.	Yams	Tubers (species dependent)	
Elaeagnus angustifolia	Russian olive	Fruit	Medicinal
Emblica officinalis (Phyllanthus emblica)	Emblic, amla	Fruit	Medicinal, ink, cleaning, dye mordant
Gonioggyna sp. (*Crotolaria* sp.)	Rattlepods	Flowers, seeds, leaves and pods (species dependent)	Fibre, fodder
Juglans regia	Walnut	Nut	Wood
Linum sp.	Linseed/flax	Oilseed	Fibre
Linum usitatissimum	Linseed/flax	Oilseed	Fibre
Linum/Safflower type?	Linseed/flax OR Safflower	Oilseed	Fibre
Mangifera sp.	Mango	Fruit	
Musa sp.	Banana	Fruit	Leaves
Papaver sp.	Poppy	Seed/oilseed	Weed, medicinal, stimulant (species dependant)
Papaver rhoeas	Field poppy	Seed/oilseed	Weed, medicinal
Phoenix sp.	Palms	Fruit, oilseed	Leaves, fibres, wood
Phoenix dactylifera	Date palm	Fruit, oilseed	Leaves, fibres, wood
Pistacia vera	Pistachio	Nut	
Prunus sp.	Stone fruits	Fruits	Wood, medicine, dye,
Prunus amygdalus	Almond	Nut	
Rorippa sp.	Yellowcresses	Stems, leaves, seeds (species dependent)	
Ricinus communis	Castor bean	Oilseed	Medicine, poison, cosmetic
Saccharum sp.	Broomsedges	Stem	
Sesamum sp.	Sesame	Oilseed	
Sesamum indicum	Sesame	Oilseed	
Sesamum malabaracum	Sesame	Oilseed	
Solanum sp.	Eggplant type	Fruit	
Tamarindus indica	Tamarind	Fruit, pulp	Medicine, polish, wood, oil
Terminalia chebula	Chebulic myrobalan	Fruit/nuts	Tanning, dye, medicine
Trigonella foenum-graecum	Fenugreek	Seeds, leaves	Fodder
Vitis vinifera	Grape	Seeds	Fodder and weed (species dependent in Vitaceae)
Zingiber sp.	Ginger	Rhizome	Medicine
Zingiberaceae	Ginger, tumeric	Rhizomes (species dependent)	Medicine
Ziziphus sp.	Jujube	Fruit	Medicine, fodder, tanning, wood

Table 8.1 List of Tier III edible plants at Indus sites, their common names and possible uses. Based on Bates (2019a, 2019b).

Latin binomial	Common name	Edible elements	Other possible uses
Ziziphus jujube	Jujube, Chinese date	Fruit	Medicine, fodder, tanning, wood
Ziziphus mauritiana	Jujube, Indian jujube	Fruit	Medicine, fodder, tanning, wood
Ziziphus nummularia	Jujube, wild jujube	Fruit	Medicine, fodder, tanning, wood
"Wild herbs"			
"Wild fruits"			
"Indeterminate fruit"			
"Indeterminate oilseed"			
"Indeterminate Tuber"			
"Fruit rind"			

Table 8.1 continued.

For example, Alamgirpur had an extremely narrow range of values, perhaps suggesting a narrower range of foods or narrower range of what the animals were being fed, while Lohari Ragho I showed values ranging from only C_4 to a mix of C_3/C_4, suggesting much greater variation in diet, either human or animal, than at other sites.

Residue analysis has given us a new insight into exactly what was being put into vessels. This remains however a broad-brush overview of what was being cooked in vessels. Microbotanical evidence is another relatively new critical tool that is helping to unpick both the actual use plants at a site, and can often provide a information to genus or something species level (preservation and taphonomy dependent – see critiques and discussions in Mercader et al 2018; Piperno 2006). Phytoliths have become a relatively common element of Indus archaeobotany, helping to unpick cereal crop processing patterns (Bates et al 2017; Madella 2003) northwest India. Current understanding of the agricultural strategies in use by populations associated with South Asia's Indus Civilisation (3200-1900 bc, fuel systems (Lancelotti et al 2017), and agricultural systems (Bates and Petrie 2016; García-Granero et al 2016; Pokharia et al 2017) but also for "finding" missing plants, those that might not survive macrobotanically. Examples of this are the discoveries of banana (*Musa* sp.) phytoliths at Bahola, Burj, Masudpur I (Bates 2016; Bates and Petrie 2016) and Kot Diji (Madella, 1997), baruwa sugarcane (*Saccharum bengalense*) at Kot Diji (Madella 1997) and fruit rind at Bahola, Burj, Dabli vas Chugta, Masudpur I and Masudpur VII (Bates 2016; Bates and Petrie 2016).

Starch on the other hand is relatively new as a technique in the Indus. Work by García-Granero et al (2017b) at Shikarpur showed how plant material was prepared on grinding stones through a comparison of microfossil analysis from the grinding stones and the macrobotanical finds from the fire-contexts. Millets were the staple crop, being processed and ground at the site for flour. Sedges, pulses and tuberous roots were also being ground as well as bring burnt whole in the fire, suggesting that there was a range of preparation techniques for these foods. This idea of how food was prepared, the creation of new textures which may have changed the way food was experienced and thus how it tasted, is important for Indus food studies, as notions of Indus cooking need to move beyond ingredients lists to thinking about all the steps from field to assemblage.

And this is something that is picked up on by Kashyap and Weber (2016, 2013, 2010; see also Weber et al 2011) in their study at Farmana. This starch work shows not only the benefits of microbotanical remains for exploring starchy foods, but also for looking into non-starchy and non-cereal/staple foods, and how foods might be combined to make new flavours within the Indus world. Through a study of food microbotanical remains trapped in dental calculus and pottery matrices, Kashyap and Weber (2010, 2013) and Weber et al (2011) demonstrated how going straight to the ceramics and teeth to look at what was cooked and ingested could allow us to move beyond taxa lists to think about how food items were combined. As with the residues discussed above, these microbotanical starch assemblages must be cautiously approached as they potentially represent palimpsests of foods consumed, in the case of the calculus, or placed into vessels at different times in the case of the ceramics, but the repetition of patterns in what is being combined is interesting and hints at possible ideas of what is good to combined and use again and again. Alongside showing the range of foods being consumed their pilot study hinted at patterns in what foods were being repeatedly combined by Indus peoples at Farmana. Lentils and wheat/barley and millets seem to be repeatedly contained in the large storage vessels, while horsegram, cf. eggplant, cf. ginger, and cf. turmeric were identified repeatedly found together in the cooking pots (Weber et al 2011; Kashyap and Weber 2010, 2013). Eggplant and mangoes were commonly found on long bladed lithics, while "spices" and "herbs" were more likely to be found in ceramics (Weber et al 2011). There was also a suggestion of different cooking practices: coarse ware ceramics seem to have good preservation while fine wares showed swelling, loss of identifying features on the starches, and aggregations potentially caused by boiling for example (Kashyap and Weber 2010, 2013).

Through these kinds of studies then we begin to see that Indus foodways theory moves us into the realm of "good to think", and the complexity of food mirrors the complexity of the agricultural and material cultural systems. Indeed, food is likely to have been another aspect of Indus identity display. Work by Chase (2010) has shown that at Bagasra in Gujarat butchery marks and cooking technologies show social differentiation in the form of inclusion and exclusion, marking people as within or outside the walls of the site. While meat was likely acquired from a common market source, different cuts of mutton and bovine were favored on either sides of the walls of the city and prepared differently. There was also differential access to piscine and shellfish resources. Madella (2014, 229) has also hypothesized that rice may have acted as "a further symbol of class identity" in Indus cities like Harappa, giving an identity aspect to the conspicuous consumption of this cereal.

8.4 Bridging the emic gap?

What we see then is Indus people combing ingredients in a myriad ways, using the Tier III plants proposed by Weber (1999) to change the ways that the bland cereal staples tasted. This is complimented by changing the textures of these through preparation techniques like grinding and boiling, and adding in non-plant elements like fats and possibly milk, but this varies by region and may not have been consistently done. This may link with regional identities, and now that more datasets macrobotanically and now data types like residues and microbotanical remains are becoming available exploring this will become easier as time goes on. We also see how Indus peoples may have understood different plant "types" and their uses in food; at Farmana for example we see that fruits like mango were being combined with vegetables like eggplant and pulses like horsegram and spices like ginger and turmeric, while at Shikarpur tubers, sedges and pulses were being ground the same as cereals. This begins to help us think about an Indus idea of what is not only good to eat in and also how to eat it.

What we don't see though is exactly the ways Indus people might have thought it right to combine them into flavoured food – how *much* turmeric and ginger should be added for example to the horsegram and eggplant at Farmana to make a good to eat food (see Kashyap and Weber 2016, 2013, 2010; Weber et al 2011), how much sweet, salt, bitter, and so on should be used with different staples, and would people at Harappa also think that ginger, turmeric, horsegram, mango and eggplant combined was a good recipe? Currently we have no way to measure quantities of ingredients being added, and the few examples of sites with such information are few and far between. What we are seeing though is that things were being added together, textures and senses changed, getting us closer to that sense of culturally valued recipes, inclusionary/exclusionary identities created, so we can start to approach the mixing of them and what the profiles of "good" might have been in different regions. And it provides an important roadmap for future study – to keep thinking beyond taxa lists, beyond just assuming the functionality of a particular plant, and to start thinking about the experiences of food for people in the past and how we might begin to link this through to the bigger cultural picture of daily life in cultures like the Indus.

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Chapter 9

The first five millennia of plant food production in the central and western Balkans: archaeobotanical evidence from the Neolithic to the Bronze Age

Dragana Filipović, Djurdja Obradović, Anne de Vareilles

Abstract

This paper takes a long-term perspective and looks at the development of plant food economies from the Neolithic through to the Bronze Age (6300-1000 BC) in the central and western parts of the continental Balkans (southeast Europe), more specifically – the territories of Serbia, *Kosovo[1], and Bosnia and Herzegovina. It does this by overviewing the archaeobotanical evidence of crop growing from sites archaeologically dated to the selected timespan. Farming started in the region with the cultivation of at least six crop species early in the Neolithic. Through time, the range grew steadily as new species were taken into cultivation whilst old ones were maintained. Some crops changed their role over time, from minor to major or vice versa, while the importance of others remained constant. Continuity, diversification and innovation mark the five millennia of farming practice in the region.

Keywords: *central and western Balkans, later prehistory, crops, archaeobotany*

9.1 Introduction

The central-western part of the Balkans is one of the oldest agricultural regions of Europe. Here, arable farming has been continuously practiced from the late 7th mill BC onwards, despite the tumultuous history of the region plagued with wars, large-scale migrations and exodus, and inter-annual scale economic downturns. Even today, agriculture is the major branch of production and is practiced both by smallholders (family run farms) and on an industrial scale. This paper looks at the first five millennia of crop cultivation in the region, from its beginnings in the Neolithic to the start of the Iron Age in the early 1st mill BC. The aim is to highlight changes evident between broad archaeological periods in terms of the cultivated crops and the expansion (or contraction) of their spectrum through time.

1 We adopt the European Commission's view on the disputed territory: "This designation is without prejudice to positions on status and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence." (https://ec.europa.eu/neighbourhood-enlargement/countries/detailed-country-information/kosovo_en Last accessed 2 April 2021).

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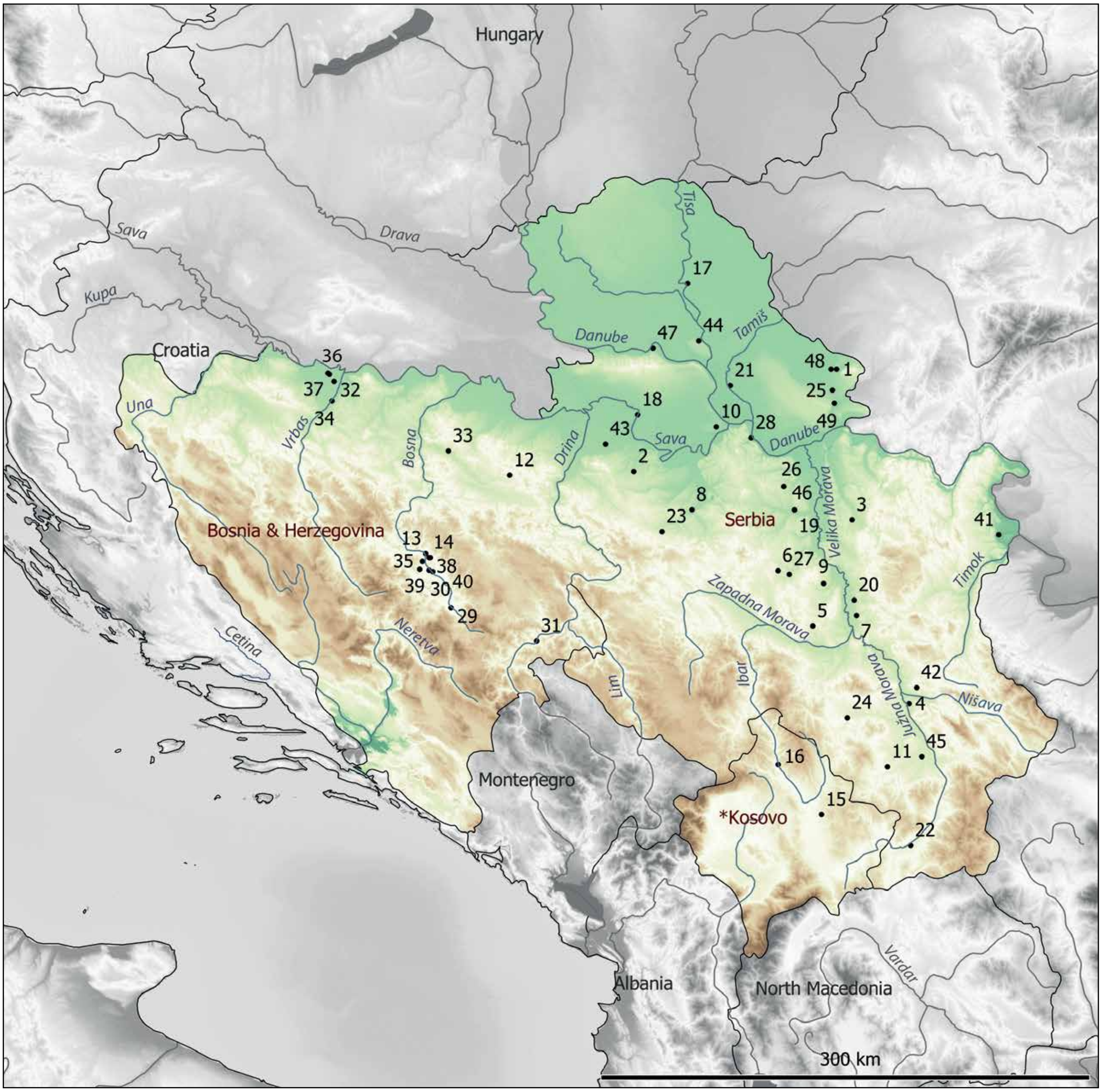

Fig 9.1 Map of the study region showing location of the sites with archaeobotanical data: 1. At 2. Belotić 3. Belovode 4. Bubanj 5. Blagotin 6. Divostin 7. Drenovac 8. Jaričište 1 9. Medjureč 10. Starčevo-Grad 11. Svinjarička Čuka 12. Gornja Tuzla 13. Kakanj 14. Obre I 15. Predionica 16. Valač 17. Bordjoš 18. Gomolava 19. Medvednjak 20. Motel Slatina 21. Opovo 22. Pavlovac-Gumnište 23. Petnica 24. Pločnik 25. Potporanj 26. Selevac 27. Vinča (Kragujevac) 28. Vinča-Belo Brdo 29. Butmir 30. Donje Moštre 31. Jagnjilo 32. Kočićevo 33. Korića Han 34. Kosjerovo 35. Kundruci 36. Laminci Jaružani 37. Laminci Jaružani-Njiva 38. Obre II 39. Okolište 40. Zagrebnice 41. Mokranjske Stene 42. Humska Čuka 43. Šanac-Izba 44. Feudvar 45. Hisar 46. Novačka Ćuprija 47. Petrovaradin 48. Vatin 49. Židovar.

9.2 The study region

In political terms, the "central and western Balkan" region of our interest here denotes the territories of modern-day Serbia, *Kosovo, and Bosnia and Herzegovina (BaH) (Fig. 9.1). Within this region, we consider archaeological sites located approximately between the 42nd and 46th parallel north and 15th and 22nd meridian east of Greenwich. These are the areas where (a) our research in the region has taken place, which ensures familiarity with and direct control of most of the archaeobotanical data; and (b) south-to-north along our study region, the climate changes from sub-Mediterranean to increasingly continental, which may have influenced the range of cultivated crops. In the phase of agricultural spread at the start of the Neolithic, the south-north environmental gradient in southeast Europe likely required adaptations of the early crops and cultivation practices to the colder and drier conditions compared to those in the Mediterranean (Halstead 1989; Ivanova et al 2018). The selected region is well-placed to capture this transition; however, we do not explore this in detail here, as we do that in a separate study (de Vareilles et al 2022; see also Gaastra et al 2019). Additionally, we look over the political borders and briefly consider the evidence from Montenegro, Albania and North Macedonia.

In geographical terms, our study region encompasses the southern end of the Carpathian Basin/Pannonian Plain (including the south section of the middle Danube), the eastern end of the Dinaric Alps (much of BaH, western Serbia and *Kosovo), the southernmost end of the Carpathians, and north-western ends of the Balkan Mountains (also known as the Stara Planina) and the Rhodopes in eastern Serbia. The region is dissected by numerous rivers, of which the major ones are the Sava, with its many tributaries in BaH and Serbia (e.g. Vrbas, Bosna, Drina, Kolubara), and the (southern section of the middle) Danube, with its key tributaries – the Drava, the Tisa and the Velika Morava. The Sava-Danube line marks the transition between the hilly to mountainous southern part and the predominantly flat northern part of the region. The northern part opens freely to central Europe and its rivers flow southwards. Rivers in the southern part mostly flow northwards, cutting through the mountains and creating basins and valleys, and forming natural communication lines between the Mediterranean (primarily Adriatic and Aegean) and continental sections of the Balkan Peninsula.

9.3 Brief Neolithic to Bronze Age culture-history

The archaeological evidence, of which the level of detail is generally low and quite varied across the region, reflects the past diversity of cultural practices. This evidence is traditionally described in the context of "cultures" differentiated based on the types, shapes and decoration of material remains (principally pottery). We here list the cultures associated with the Neolithic, Eneolithic (Copper Age) and Bronze Age (Tables 9.1-9.2) with a comment on the availability of archaeobotanical data.

9.3.1 Neolithic

Neolithic lifeways began here in the second half of the 7th mill cal BC and were led by relatively small communities designated as the Starčevo culture, which resided here until the second half of the 6th mill BC. Nearly a hundred Starčevo sites have been documented in the region, of which the vast majority are in Serbia and only a few in Kosovo and BaH, largely reflecting the low level of research and reporting, as well as high levels of erosion and destruction in modern times (Garašanin 1979; Srejović 1988; Tasić 1997). Many Starčevo sites were registered solely on the basis of ceramic scatters, eliminating the prospect of archaeobotanical sampling, although plant impressions in ceramics and daub were sometimes noted. Where excavations were possible, in most cases they took place decades ago and, in the absence of adequate expertise, did not include recovery of plant remains. There are, however, several exceptions, along with more recent excavations incorporating archaeobotanical analysis.

Around the mid-6th mill BC, the Starčevo culture underwent change or terminated, and a new phenomenon emerged, known as the Vinča culture (Garašanin 1979), which lasted to around 4500 cal BC (Borić 2009, 2015). At the peak of its development, it extended through the entire central and part of western Balkans, from southernmost Hungary to northern North Macedonia, and from easternmost Croatia and north-eastern BaH to western parts of Transylvania (Garašanin 1979; Chapman 1981; Borić 2015). Excavations of Vinča sites have frequently included archaeobotanical sampling and analysis.

The mid-6th mill BC in central BaH is described as the time when Starčevo was replaced by, or developed into, the Kakanj culture, documented at several sites in the lower-middle course of the Bosna River, including the key site of Obre I, where Kakanj layers sit directly on layers that combine elements of Starčevo and Adriatic-Impresso cultures (Benac 1979). The Butmir culture developed in the west simultaneously to the Vinča culture in the east. Some settlements were excavated long ago – Butmir, for instance, was first excavated at the end of the 19th c – and concentrations of plant remains (in pots) were collected for analysis. Imprints of plant parts on the surface of pots and daub were noted or studied. Recent investigations have included structured archaeobotanical research.

9.3.2 Eneolithic

At the turn of the 6th to 5th mill BC, the first copper smelting took place in Europe, in the context of the Vinča culture, in eastern Serbia (Radivojević et al 2010). Traditionally, the end of Vinča and the last phase of Butmir cultures, at c.4500 cal BC, are taken as the onset of the period termed Copper Age or Eneolithic (Jovanović 1979; Perić 1995; Borić 2009, 2015). The centuries around the mid-5th mill BC witnessed the abandonment of many settlements and, simultaneously, the colonisation of new areas considered by some as agriculturally marginal (Chapman 1990). A host of new cultural traditions were identified as developing across the region (Table 9.1), some starting synchronously with the younger phases of the Neolithic cultures, some derived from these and evolving into new phenomena. The majority of Eneolithic sites were excavated in the period between World War II and the Yugoslav civil wars in the

ENEOLITHIC, ca 4400-2500 BC	
Culture	Distribution in the study region
mid-5th – early 4th mill BC	
Tiszapolgár Bodrogkeresztúr	Higher ground in the Tisa and the Sava River valleys in Serbia (mainly cemeteries registered)
Lasinje	Northern Bosnia, in the low-lying Sava valley
Baden	Northern Bosnia and Vojvodina (along the Sava and its tributaries, and the Danube) and around the Velika Morava confluence
Bubanj-Sălkuţa-Krivodol	East and south of the Velika Morava in Serbia, and *Kosovo
4th and first half of 3rd mill BC	
Cernavodă III-Boleráz	Along the Danube and in central and eastern Serbia
Kostolac-Coţofeni	Across much of Serbia and eastern Bosnia
Vučedol	Emerged in northern Croatia and northwestern Serbia (Slavonia and Srem regions), spread to west, east and south, covering the northern and western parts of the study region
Corded Ware and Yamnaya	Sporadic finds across the study region of: corded ceramic ware, horse-head sceptres, burials under mounds, horse remains
References: Tasić 1995; Marijanović 2003; Bulatović et al 2018; Miloglav 2018; Koledin et al 2020	

Table 9.1 Summary of Eneolithic cultures and their distribution in the study region.

1990s, during which archaeobotanical investigations were rarely included in the research. However, in the last couple of decades, excavations of some key sites have integrated archaeobotanical fieldwork and analysis.

9.3.3 Bronze Age

The diversity in material culture of the region grew even further during the 3rd and 2nd mill BC. More cultural traditions existed in the ca 1500 years of the Bronze Age than in the preceding 4000 years. The emergence of so many material culture styles (Table 9.2), with both distinctive and shared characteristics, is a reflection of the intensive interaction between groups within the region as well as between the Mediterranean and central and eastern Europe, with the cross-continental trade routes traversing the central-western Balkans (e.g. Sherratt 1993). Traditionally, the second half of the 3rd mill BC is taken as the time when Bronze Age developments began in the region (Garašanin 1982, 1983a-c). However, the last centuries of the 4th mill BC (the Kostolac-Coţofeni culture) have recently been relegated to the Bronze Age of the central Balkans, in order to align the local chronologies with those used in the neighbouring countries (Bulatović et al 2020). Some settlements were occupied during one phase of the period, or by one cultural group, others for (much) longer and by different cultures (e.g. Feudvar – Falkenstein et al 2016). Investigated Bronze Age sites are generally in a poor state of preservation, particularly those from the early part of the period. The cultural layers are often affected by erosion and modern-day agricultural use

BRONZE AGE, ca 2500-1000 BC	
Culture	Distribution in the study region
mid-3rd – start of 2nd mill BC	
Maros	Banat (Serbia)
(Somogyvár-) Vinkovci	Srem (Serbia), along the Sava in northern Bosnia
Belotić-Bela Crkva	Western Serbia (only cemeteries registered)
Bubanj-Hum III	Central and southern Serbia
Armenochori	Southernmost Serbia
Glasinac	Eastern Bosnia, upper course of the Neretva, Bosna, Vrbas rivers
Cetina	South-eastern Bosnia
2nd mill BC	
Vatin	Vojvodina, central Serbia, northern Bosnia
Transdanubian Encrusted Pottery	Srem, the Sava-Danube confluence
Verbicioara	Eastern Serbia
Dubovac-Žuto Brdo	Along the Danube in eastern Serbia
Tumulus (Hügelgräber)	Bačka and Banat (Serbia)
Paraćin	Middle course of the Velika Morava River and lower course of the Južna Morava River
Bubanj-Hum IV – Ljuljaci	Central and western Serbia
Dinaric	South-western Bosnia
Glasinac	Eastern Bosnia
Urnfield	Northern Bosnia, the Sava-Danube interfluve in Vojvodina, western Serbia
Middle-Bosnian	Central Bosnia, upper and middle course of the Bosnia and Vrbas rivers
Dalmatian	South/south-western Bosnia
Donja Brnjica	Southern and south-western Serbia (the Južna Morava River, Sandžak region), and *Kosovo
Brezjak	Western Serbia
Belegiš II-Gáva	Local Urnfield variant (transition to the Iron Age)
References: Garašanin 1982, 1983a-c; Govedarica 1989; Tasić 2004; Ljuština 2012; Gligorić et al 2016; Bulatović et al 2018, 2020; Bulatović 2020	

Table 9.2 Summary of Bronze Age cultures and their distribution in the study region.

or have been truncated by post-Bronze Age occupations. In the 1980s, archaeobotanical sampling and recovery was conducted at a few Bronze Age settlements in Serbia, and at several others more recently; currently, only a single archaeobotanical sample has been taken in BaH (at the site of Kosjerovo – de Vareilles 2018).

9.4 The archaeobotanical evidence: materials and methods

The number of sites in the region from which archaeobotanical material has been retrieved, analysed and published has increased during the last 15 years (Table 9.3), although it is still low compared to, for

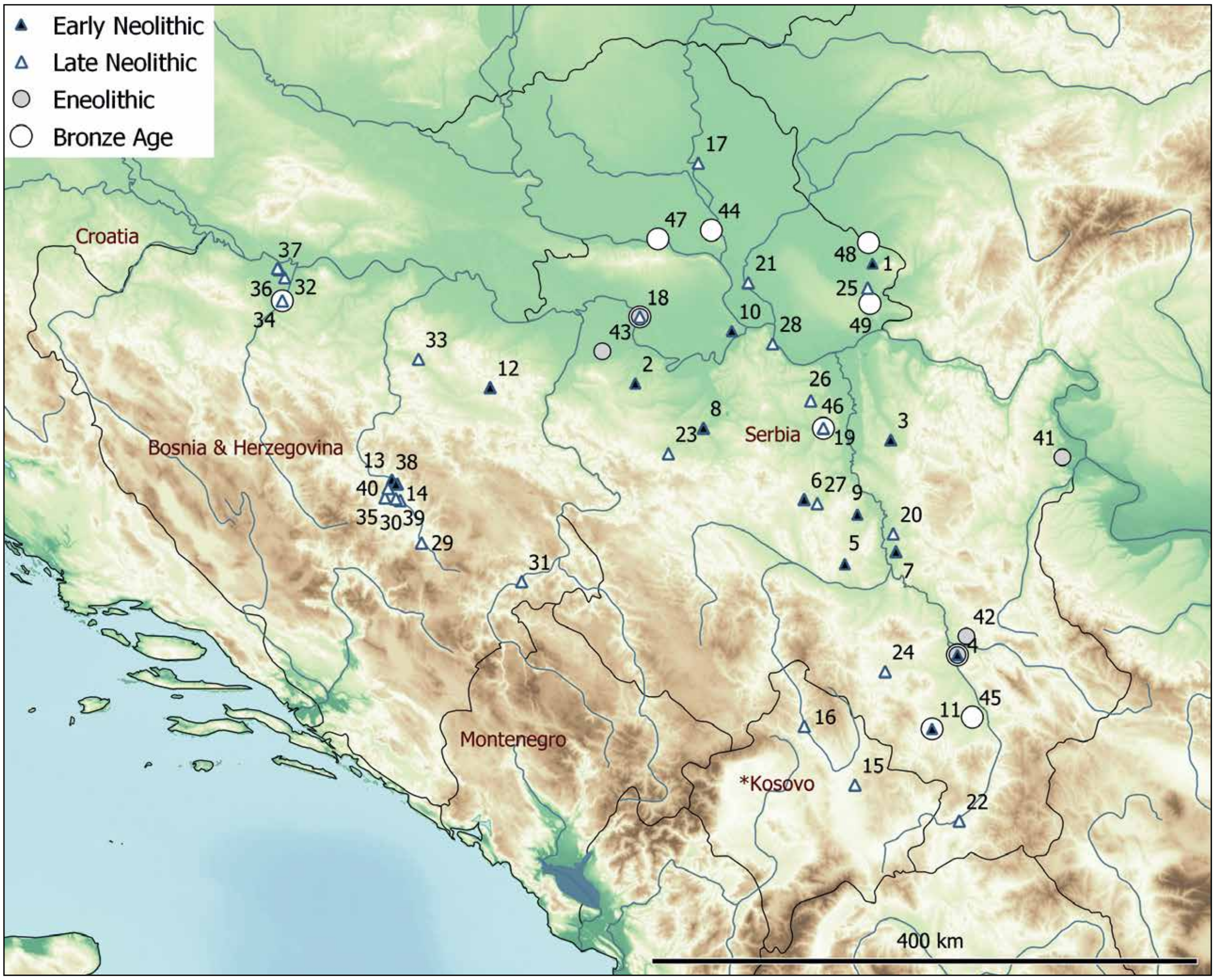

Fig 9.2 Archaeobotanical coverage of the region for the considered periods. For site names see caption for Fig. 9.1.

instance, central-western Europe. The coverage of the area is strikingly uneven (Fig. 9.2), which is dictated by the lack of research, research funds or archaeobotanical expertise.

We note the presence of cultivated taxa based on the archaeobotanical remains (seed/fruit/chaff) and imprints in pottery and daub (Table 9.4). The latter allow us to include more sites in this overview whilst relying on the proven expertise of renowned archaeobotanists Maria Hopf and Jane Renfrew (Hopf 1958, 1967, 1974; Renfrew 1974, 1979). The archaeobotanical remains are predominantly charred; mineralised preservation is occasionally reported.

So far, forty-nine sites in the central and western Balkans have offered sixty-two archaeobotanical datasets dated to the time between ca 6300 and ca 1000 BC. All of the sites are open-air settlements and the majority located in places of modern-day human habitation or agricultural activity. Many were used in or throughout different periods, some up to medieval times, and have a thick, diachronic cultural layer. In these cases, and particularly where the layers from different periods are directly superimposed, there is a possibility that some archaeobotanical remains have moved between the layers/periods due to natural or anthropogenic activities. This has most clearly been proven for the grains of broomcorn millet, through the radiocarbon AMS-dating of the grains themselves. Following the most recent results, demonstrating the presence of broomcorn millet in Europe not earlier than the mid-2nd mill BC (Filipović et al 2020), we have disregarded the records of millet in pre-Bronze Age contexts.

In addition to site formation processes, and the inherently selective preservation through charring (biased towards plant parts exposed to heating, and the hard/sturdy ones), the various methods of archaeobotanical recovery have also shaped the datasets (see Table 9.3). Therefore, we here record only presence/absence of crops, but are fully aware that this can undermine or exaggerate

	SITE	N	E	COUNTRY	Number of samples	Total sample volume (L)	Sampling	Hand-picking	From pollen sample	Imprint	Archaeobotany reference
EARLY NEOLITHIC, ca 6300-5500 BC											
1	At	45.136	21.281	Serbia	10	100	Y				de Vareilles 2018
2	Belotić	44.577	19.718	Serbia				Y			Borojević 1990
3	Belovode	44.311	21.401	Serbia	7	42	Y				Filipović 2021a
4	Bubanj	43.290	21.840	Serbia	5	50	Y				Filipović 2020
5	Blagotin	43.723	21.098	Serbia			Y				Jezik 1998
6	Divostin I	44.030	20.830	Serbia					Y		Grüger and Beug 1988
7	Drenovac	43.782	21.435	Serbia	63	524.3	Y				Obradović 2020
8	Jaričište 1	44.367	20.167	Serbia	7	55	Y				Borojević and Sheridan submitted
9	Medjureč	43.959	21.181	Serbia	10	30	Y				Filipović and Obradović 2013
10	Starčevo-Grad	44.822	20.354	Serbia	3	30	Y			Y	Renfrew 1979; Medović 2011
11	Svinjarička Čuka	42.934	21.673	Serbia	1	24	Y				Horejs et al 2019
12	Gornja Tuzla	44.557	18.762	BaH						Y	Hopf 1967
13	Kakanj	44.125	18.115	BaH	4		Y				Renfrew 1974
14	Obre I	44.103	18.141	BaH	23		Y				Renfrew 1974
LATE NEOLITHIC, ca 5400-4500 BC											
15	Predionica	42.664	21.165	*Kosovo						Y	Hopf 1974
16	Valač	42.947	20.831	*Kosovo				Y			Hopf 1974
17	Belovode	44.311	21.401	Serbia	41	257	Y				Filipović 2021a
18	Bordjoš	45.600	20.133	Serbia			Y				Medović et al 2019
19	Divostin II	44.030	20.830	Serbia					Y		Grüger and Beug 1988
20	Drenovac	43.782	21.435	Serbia	440	3672.5	Y				Obradović 2020
21	Gomolava	44.888	19.748	Serbia	41		Y				van Zeist 2002
22	Jaričište 1	44.367	20.167	Serbia	2	17	Y				Borojević and Sheridan submitted
23	Medvednjak	44.366	20.957	Serbia	6			Y			Renfrew 1979; Obradović 2020
24	Motel Slatina	43.867	21.417	Serbia	2	1.7	Y				Filipović and Obradović 2013
25	Opovo	45.047	20.462	Serbia	267	2916	Y				Borojević 2006
26	Pavlovac-Gumnište	42.489	21.852	Serbia	185	1664.5	Y				Obradović 2020
27	Petnica	44.246	19.936	Serbia				Y			Borojević 1990
28	Pločnik	43.210	21.364	Serbia	68	479	Y				Filipović 2021b
29	Potporanj	45.022	21.249	Serbia	11	110	Y				de Vareilles 2018
30	Selevac	44.495	20.874	Serbia	53		Y	Y			Hopf 1974; McLaren and Hubbard 1990; Obradović 2020
31	Vinča (Kragujevac)	44.010	20.917	Serbia						Y	Hopf 1974
32	Vinča-Belo Brdo	44.762	20.623	Serbia	195	2281.5	Y				Filipović et al 2019
33	Butmir	43.824	18.310	BaH			Y				Renfrew 1979
34	Donje Moštre	44.025	18.170	BaH	47		Y				Kroll 2013b
35	Gornja Tuzla	44.557	18.762	BaH				Y		Y	Hopf 1967,1974
36	Jagnjilo	43.640	18.970	BaH	185		Y				de Vareilles 2018; Kroll submitted
37	Kočićevo	45.070	17.409	BaH	16	90.5	Y				de Vareilles 2018
38	Korića Han	44.690	18.290	BaH	1			Y			de Vareilles 2018
39	Kosjerovo	44.963	17.393	BaH	26	412	Y				de Vareilles 2018
40	Kundruci	44.038	18.069	BaH	29		Y				Kroll 2013b
41	Laminci Jaružani	45.108	17.373	BaH	2	144	Y				de Vareilles 2018
42	Laminci Jaružani-Njiva	45.114	17.362	BaH	2	56	Y				de Vareilles 2018
43	Lisičići	43.700	17.896	BaH						Y	Hopf 1958, 1967
44	Lug (Goražde)	43.643	18.990	BaH				Y		Y	Hopf 1967

Table 9.3 Neolithic, Eneolithic and Bronze Age sites with archaeobotanical data. Note that some sites were occupied in more than one period (* value converted from kg).

	SITE	N	E	COUNTRY	Number of samples	Total sample volume (L)	Sampling	Hand-picking	From pollen sample	Imprint	Archaeobotany reference
45	Obre II	44.103	18.151	BaH	14		Y				Renfrew 1974
46	Okolište	44.033	18.141	BaH	58		Y				Kroll 2013a; Kroll pers. comm.
47	Zagrebnice	44.082	18.090	BaH	28		Y				Kroll 2013b
ENEOLITHIC, ca 4400-2500 BC											
48	Bubanj	43.290	21.840	Serbia			Y				Filipović 2020
49	Gomolava	44.888	19.748	Serbia	10		Y				van Zeist 2002
50	Humska Čuka	43.379	21.899	Serbia	8	80	Y				Bulatović and Filipović 2022
51	Mokranjske Stene	44.229	22.531	Serbia	1	10	Y				Filipović 2015
52	Šanac-Izba	44.727	19.501	Serbia	34	270	Y				Tripković et al 2017
BRONZE AGE, ca 2400-1000 BC											
53	Bubanj	43.290	21.840	Serbia	4	50	Y				Filipović 2020
54	Feudvar	45.290	20.219	Serbia	510		Y				Kroll 2016
55	Gomolava	44.888	19.748	Serbia	1		Y				Medović 2016
56	Hisar	42.991	21.938	Serbia	64	448	Y				Medović 2012
57	Novačka Ćuprija	44.366	20.957	Serbia	38	2900*	Y				Bankoff and Winter 1990
58	Petrovaradin	45.250	19.867	Serbia	7		Y	Y			Medović 2016
59	Svinjarička Čuka	42.934	21.673	Serbia	6	150	Y				Horejs et al 2019
60	Vatin	45.232	21.254	Serbia	21	231	Y	Y			Filipović and Jovanović 2018
61	Židovar	44.950	21.264	Serbia	21	210	Y				Medović 2003
62	Kosjerovo	44.963	17.393	BaH	1	12	Y				de Vareilles 2018

Table 9.3 continued.

TAXON / SITE	Einkorn	Emmer	Einkorn/emmer (where no einkorn or no emmer)	Timopheev's wheat	Free-threshing wheat	Bread wheat	Tetraploid free-threshing wheat	Barley naked	Barley hulled	Barley indeterminate	Flax/linseed	Lentil	Pea	Bitter vetch	Spelt	Rye	Gold-of-pleasure	Opium poppy	*Lallemantia*	Grass pea	Broad bean	Broomcorn millet	Foxtail millet
T. = *Triticum*; *H.* = *Hordeum*	*T. monococcum*	*T. dicoccum*	*T. monococcum* or *T. dicoccum*	*T. timopheevii* s.l.	*T. durum/ aestivum*	*T. aestivum*	*T. durum*	*H. vulgare nudum*	*H. vulgare vulgare*	*H. vulgare*	*Linum usitatissumum*	*Lens culinaris*	*Pisum sativum*	*Vicia ervilia*	*T. spelta*	*Secale cereale*	*Camelina sativa*	*Papaver somniferum*	*Lallemantia iberica*	*Lathyrus sativus/cicera*	*Vicia faba*	*Panicum miliaceum*	*Setaria italica*
EARLY NEOLITHIC, ca 6300-5500 BC																							
At	x		x	cf.					x														
Belotić					x			cf.	x														
Belovode	x	x		x						x		x	x										
Bubanj		x	x							x													
Blagotin	x	x								x		x											
Divostin I		x																					
Drenovac	x	x							x			x	x										
Jaričište 1		x								x		x	x										
Medjureč	x	x								x		x											
Starčevo-Grad	x	x			imp.					x			imp.										

Table 9.4 Crops recorded at Neolithic, Eneolithic and Bronze Age sites in the region; "imp." = imprints, "cf." = tentative identifications.

TAXON / SITE	**Einkorn**	**Emmer**	**Einkorn/emmer (where no einkorn or no emmer)**	**Timopheev's wheat**	**Free-threshing wheat**	**Bread wheat**	**Tetraploid free-threshing wheat**	**Barley naked**	**Barley hulled**	**Barley indeterminate**	**Flax/linseed**	**Lentil**	**Pea**	**Bitter vetch**	**Spelt**	**Rye**	**Gold-of-pleasure**	**Opium poppy**	*Lallemantia*	**Grass pea**	**Broad bean**	**Broomcorn millet**	**Foxtail millet**
T. = *Triticum*; *H.* = *Hordeum*	*T. monococcum*	*T. dicoccum*	*T. monococcum* **or** *T. dicoccum*	*T. timopheevii* **s.l.**	*T. durum/ aestivum*	*T. aestivum*	*T. durum*	*H. vulgare nudum*	*H. vulgare vulgare*	*H. vulgare*	*Linum usitatissumum*	*Lens culinaris*	*Pisum sativum*	*Vicia ervilia*	*T. spelta*	*Secale cereale*	*Camelina sativa*	*Papaver somniferum*	*Lallemantia iberica*	*Lathyrus sativus/cicera*	*Vicia faba*	*Panicum miliaceum*	*Setaria italica*
Svinjarička Čuka		x	x	x					x	x													
Gornja Tuzla			imp.																				
Kakanj	x	x			x					x			x										
Obre I	x	x			x							x	x										
Predionica		imp.																					
Valač													x										
LATE NEOLITHIC, ca 5400-4500 BC																							
Belovode	x	x		x	x	x				x	x	x	x	x						x			
Bordjoš	x	x		x						x			x										
Divostin II					x															cf.			
Drenovac	x	x		x	x					x	x	x	x	x									
Gomolava	x	x			x				x		x	x	x										
Jaričište 1		x		x							x												
Medvednjak	x	x				x						x		x									
Motel Slatina	x	x										x											
Opovo	x	x		cf.					x		x	x											
Pavlovac-Gumnište	x	x		x	x				x	x	x	x	x	x						x			
Petnica	x	x						x	x														
Pločnik	x	x		x	x	x	x	x		x	x	x	x	x						x			
Potporanj	x	x		cf.	x							x											
Selevac	x	x							x			x	x										
Vinča (Kragujevac)		imp.																					
Vinča-Belo Brdo	x	x		x	x					x	x	x	x	x									
Butmir	x					x			x			x	x										
DonjeMoštre	x	x			x			x	x	x	x	x	x										
Gornja Tuzla	x	x																					
Jagnjilo	x	x			x			x	x	x	x	x	x	x	cf.					x			
Kočićevo	x	x			x				x	x			x										
Korića Han	x	x						x		x		x				x							
Kosjerovo	x	x							x														
Kundruci	x	x						x		x										x			
Laminci Jaružani	x										x												
Laminci Jaružani-Njiva			x																				
Lisičići	imp.	imp.							imp.	imp.													
Lug (Goražde)	imp.	imp.						x	x	imp.													

Table 9.4 continued.

TAXON / SITE	**Einkorn**	**Emmer**	**Einkorn/emmer (where no einkorn or no emmer)**	**Timopheev's wheat**	**Free-threshing wheat**	**Bread wheat**	**Tetraploid free-threshing wheat**	**Barley naked**	**Barley hulled**	**Barley indeterminate**	**Flax/linseed**	**Lentil**	**Pea**	**Bitter vetch**	**Spelt**	**Rye**	**Gold-of-pleasure**	**Opium poppy**	***Lallemantia***	**Grass pea**	**Broad bean**	**Broomcorn millet**	**Foxtail millet**
T. = Triticum; H. = Hordeum	*T. monococcum*	*T. dicoccum*	*T. monococcum* **or** *T. dicoccum*	*T. timopheevii* **s.l.**	*T. durum/ aestivum*	*T. aestivum*	*T. durum*	*H. vulgare nudum*	*H. vulgare vulgare*	*H. vulgare*	*Linum usitatissumum*	*Lens culinaris*	*Pisum sativum*	*Vicia ervilia*	*T. spelta*	*Secale cereale*	*Camelina sativa*	*Papaver somniferum*	*Lallemantia iberica*	*Lathyrus sativus/cicera*	*Vicia faba*	*Panicum miliaceum*	*Setaria italica*
Obre II	x	x					x	x	x			x											
Okolište	x	x		cf.		x	x	x	x	x	x	x	x			x							
Zagrebnice	x	x						x	x	x	x				x								
ENEOLITHIC, ca 4400-2500 BC																							
Bubanj	x	x							x	x	x	x	x	x									
Gomolava	x	x				x		x		x	x	x		x									
Humska Čuka	x	x							x	x		x		x	cf.								
Mokranjske Stene	x	x						x		x		x	x										
Šanac-Izba	x	x																					
BRONZE AGE, ca 2500-1000 BC																							
Bubanj	x		x							x						x							
Feudvar	x			x		x		x	x		x	x	x	x	x		x	x	x	x	x	x	x
Gomolava	x			x					x						x						x		
Hisar	x	x			x			x	x		x	x	x	x	x		x		x		x	x	x
Novačka Ćuprija	x	x				x				x		x	x	x								x	
Petrovaradin	x	x				x			x				x										x
Svinjarička Čuka	x	x								x	x	x										x	
Vatin	x	x		x	x				x		x	x	x	x	cf.	x	cf.		x			x	x
Židovar	x	x		x		x			x			x	x	x	x		x		x			x	
Kosjerovo	x		x															x					

Table 9.4 continued.

the relevance of a cultivated resource. However, we adopt this approach here as we are indeed interested specifically in the presence, not importance, of different crop taxa and their spatial distribution in different periods of later prehistory.

Sampling was conducted at the majority of the sites; however, the volume of processed soil is seldom recorded. Some sites are represented only by the material visible to and collected by the excavators or pollen analysts (i.e. recovered without sampling and sieving); at several sites, only impressions were reported. In these cases (i.e. where there was no sampling), the datasets are particularly unlikely to represent the full suite of cultivated plant foods. Certainly, for these sites, and possibly for others too, the noted taxa *presence* does not necessarily imply taxa *absence*. Nevertheless, for each of the periods included, at least some if not all of the sites have been subjected to archaeobotanical sampling and careful recovery (in many cases performed by us), thus offering a more representative picture of plant use per period. We, therefore, describe the data by archaeological period, not individual sites. This also mitigates the bias incurred from the different archaeological contexts sampled at different sites. Namely, although the contexts included are houses, pits, fire installations, storage facilities and occupation layers, not all of these are represented among the archaeobotanical samples from each site. Moreover, even the comparison between periods is done with caution, since the number of sites and samples per period varies, as does the geographical coverage.

SITE	Dated material (plant = charred)	Laboratory code	Radiocarbon age (BP)
Blagotin (pit dwelling [ZM-zemunica] No.7)	Red deer antler	OxA-8608	7480 ± 55
	Human infant bone	OxA-8609	7270 ± 50
	Bone perforator	OxA-8760	7230 ± 50
Medjureč (trench 1, square 1)	*Ovis/Capra*, pelvis sin.	BRAMS-2250	7313 ± 29
	Bos taurus, intermedium	BRAMS-2254	7266 ± 28
	Bos taurus, Ph II	BRAMS-2248	7225 ± 31
	Bos taurus, ulnare dext.	BRAMS-2249	7225 ± 31
	Bos sp., scapula	BRAMS-2247	7212 ± 31
Medjureč (trench 1, square 2)	*Bos taurus*, vertebra lumbal	BRAMS-2251	7316 ± 29
	Bos taurus, mandibular sin.	BRAMS-2252	7208 ± 29
Medjureč (trench 1, square 4)	*Ovis/Capra*, pelvis dext.	BRAMS-2253	7308 ± 29
Svinjarička Čuka (SU 26, Starčevo context)	1 (hulled) barley grain	MAMS-40136	6734 ± 25
Svinjarička Čuka (SU 22, Starčevo context)	1 emmer grain	MAMS-40137	6611 ± 24
	1 barley grain	MAMS-40138	6597 ± 24
At (Starčevo context, bottom of pit-dwelling)	charcoal	COL-3247	6868
	Bos taurus, metapodial	OxA-8594	6615 ± 70
Zagrebnice (context 10390, feature 10081)	1 emmer grain	KIA-45627	6565 ± 30
Zagrebnice (context 34060, feature 34002)	flax seeds	KIA-45630	5895 ± 35
Pločnik (horizon 5, feature 39, NE room)	1 cf. einkorn grain	MAMS-22093	6145 ± 26
Obre I (occupation phase B, start of Kakanj culture)	*Bos taurus*	OxA-23291	6665 ± 35
	Bos taurus	OxA-23292	6432 ± 35
	charcoal	UCLA-1605 F	6430 ± 60
	Sus scrofa	OxA-23290	6421 ± 35
	Bos taurus	OxA-23289	6390 ± 34
Jaričište 1 (sector 66, quad. M12, trench 39)	1 Cornelian cherry (*Cornus mas*) fruit	NOSAMS OS-78624	6660 ± 35
Jaričište 1 (sector 54-55, quad. U25, trench 57)	12 flax seeds	NOSAMS OS-78623	6260 ± 35
Belovode (Starčevo horizon)	charcoal	MAMS-22078	6422 ± 23
Drenovac (burnt Starčevo structure)	Medium/large mammal long bone/ metapodial	BRAMS-2245	7133 ± 27

Table 9.5 Details on the radiocarbon-dated finds of crops or associated materials from the Neolithic sites in the region.

Where available, we highlight the radiocarbon-dated earliest occurrences of crops, either the dates obtained directly on the plant remains or on material with which they were associated (i.e. found in the same archaeological feature or layer). The details for these dates are given in Table 9.5.

9.5 Results and discussion: The first five millennia of plant food production in the central and western Balkans

9.5.1 Neolithic

In the central and western Balkans, no less than nineteen crop species were associated with prehistoric agriculture (Table 9.4). At least six were cultivated from the earliest days of food production, the Early Neolithic, and continued to be cultivated throughout the period covered here (Fig. 9.3). The initial, diverse suite of crops persisted for five millennia. Most of these "first" crops co-occur at many of the sites, making the regional picture of diversity discernible also at the local scale. They may have been cultivated, or at least consumed already in the final centuries of the 7th mill BC.

The radiocarbon dates (Table 9.5) obtained directly on grains/seeds, or relating to the deposits containing crop remains, suggest that hulled wheats (einkorn, emmer and Timopheev's wheat) and barley (hulled type) were present in the region at the end of the 7th and very early in the 6th mill BC. Einkorn grains were discovered in a Starčevo pit dwelling at Blagotin, from which human and animal remains were radiocarbon dated to between 6440 and 5990 cal BC (Whittle et al 2002); recent dates on faunal remains from Blagotin are somewhat later (Porčić et al 2020, SI 2). The site of Medjureč has only an Early Neolithic occupation, for which the radiocarbon dates on animal bones suggest a start after around 6200 cal BC (Porčić et

Published calibrated date	Comment	Source
6440 BC (95.4%) 6230 BC		
6230 BC (95.4%) 6020 BC	Einkorn and emmer grain discovered in the same Starčevo pit-dwelling	Jezik 1998, Table 4; Whittle et al 2002
6220 BC (95.4%) 5990 BC		
	Archaeobotanical samples taken from these excavation units yielded hulled wheat and barley grains	Filipović and Obradović 2013; Porčić et al 2020
6232 BC (95.4%) 6087 BC		
5706 BC (95.4%) 5620 BC	Timopheev's wheat chaff and emmer grain found in the same sample	
5616 BC (95.4%) 5494 BC		Horejs et al 2019
5613 BC (95.4%) 5486 BC		
5842 BC (95.4%) 5668 BC	A cf. Timopheev's wheat grain found in the same Starčevo pit-dwelling	Whittle et al 2002; Chu et al 2016; de Vareilles 2018
5607 BC (95.4%) 5477 BC	From Butmir culture layer but Kakanj culture pottery also found	Müller-Scheeßel and Hofmann 2013; Vander Linden et al 2014
	From Butmir culture horizon	Müller-Scheeßel and Hofmann 2013
5207 BC (95.4%) 5009 BC	Tetraploid free-threshing wheat chaff concentration found in the oven fill from which the dated grain derived	Filipović 2021b; Marić et al 2021
Obre IB is bounded between 5666-5536 cal BC (68.2%) and 5410-5278 cal BC (68.2%)		
	Emmer and compact free-threshing wheat grains found in the layer attributed to this phase (in trench VI, level 5)	Gimbutas 1974; Renfrew 1974, 47; Vander Linden et al 2014
5639 BC (95.4%) 5523 BC	Lentil and pea found in the Starčevo grave from which the fruit derived	Marić 2013; Borojević and Sheridan submitted
5318 BC (95.4%) 5206 BC	The seeds were found in a Vinča culture pit	
Modelled start of Starčevo horizon 5648-5338 cal BC (2σ)	Lentil and pea documented in the Starčevo layer	Filipović 2021a; Marić et al 2021
	Concentration of lentils and cache of peas found in the same context	Filipović et al 2018; Obradović 2020; Porčić et al 2020

al 2020). The small collection (ca 50) of hulled wheat and barley grains recovered are, therefore, not older than the last centuries of the 7th mill BC. The starch and phytolith evidence preserved in dental calculus of individuals buried at Early Neolithic sites in the Danube Gorges shows that cereals were here consumed from about 6000 cal BC (Jovanović et al 2021).

A Starčevo context at Svinjarička Čuka yielded a (likely hulled) barley grain directly dated to 5706-5620 cal BC. Timopheev's wheat chaff and emmer grains were found in the same sample. Further north, at At, a tentatively identified Timopheev's wheat grain came from a Starčevo context dated to 5842-5668 cal BC. This species is a relatively recent discovery in archaeobotany (Jones et al 2000) so its apparent absence at sites analysed prior to its recognition must be revisited. One emmer grain from Svinjarička Čuka was directly dated to 5616-5494 cal BC and one from Zagrebnice to 5607-5477 cal BC (Müller-Scheeßel and Hofmann 2013). Belotić was described as a late Starčevo site but the grains derived from an unclear location (perhaps from mixed fill of a pit) and their association with the context (and the period) is unconfirmed (Borojević 1990, 74).

One or more free-threshing wheat species were also a component of the basic crop suite, though perhaps not from the outset. In Serbia, first records of free-threshing wheat could be the four bread wheat grains reported for Belotić and the imprint of grain in pottery at Starčevo-Grad, but both their age and identification are questionable. Earliest secure records of free-threshing wheat from Serbia are those from the Late Neolithic/Vinča culture site of Pločnik. Here, a tetraploid-type chaff concentration was found in an oven fill dated to 5207-5009 cal BC (Filipović 2021b; Marić et al 2021). In BaH, Renfrew (1974) discovered small amounts of *Triticum compactum* (club wheat) at Obre I (trench VI, level 5) and Kakanj (trench II, level 6). At Obre I, the layer is attributed to the site-phase B, ca 5600-5400 cal BC (Gimbutas 1974), or, modelled using new and old radiocarbon dates, from 5666-5536 cal BC to 5410-5278 cal BC (Vander Linden et

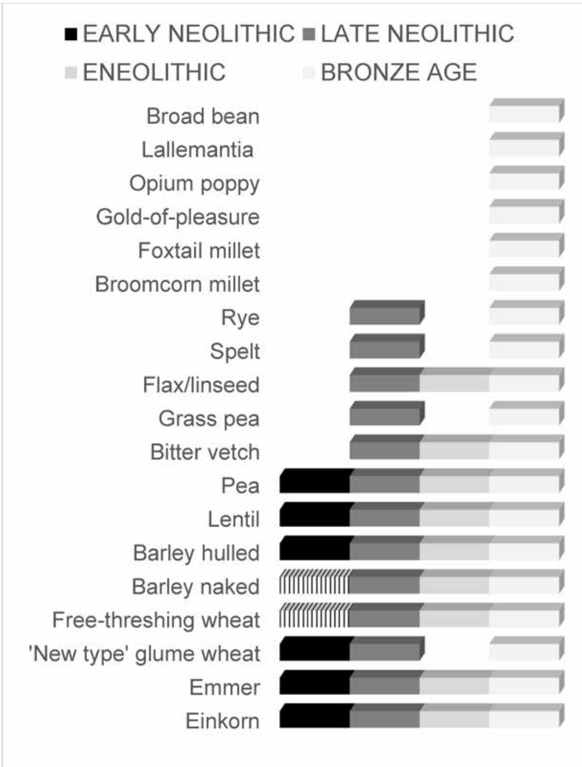

Fig. 9.3 Diachronic development of the crop spectrum in the study region (pattern fill denotes unconfirmed identification or period).

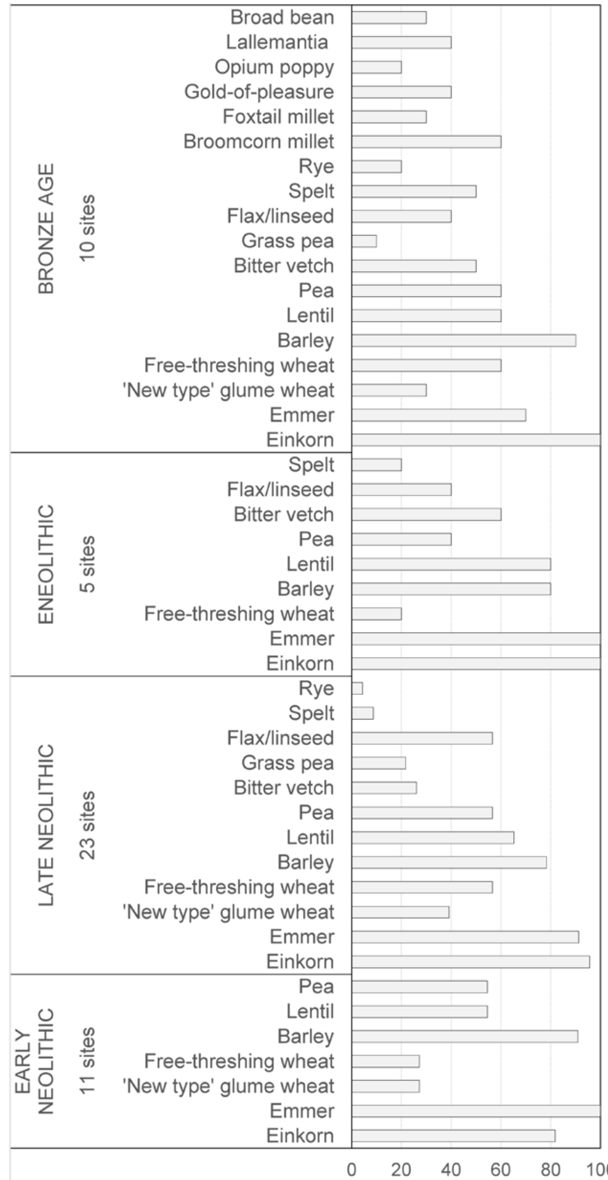

Fig 9.4 Percentage ubiquity of crop types in different periods based on the sites where archaeobotanical sampling was employed.

al 2014). Obre IB is associated with the first phase of the Kakanj culture. Free-threshing wheat was also found at other Late Neolithic sites in the region, including both tetraploid and hexaploid species.

Pulses were a part of the basic crop spectrum from the start. Lentil and pea from Jaričište 1 came from a Starčevo grave from which Cornelian cherry (*Cornus mas*) fruit stone fragments were dated to 5639-5523 cal BC (Marić 2013; Borojević and Sheridan submitted). They were also present in the Starčevo layer at Belovode placed in the period 5648-5338 cal BC (Marić et al 2021). Most prominently, concentrations of lentils and peas, likely to have been stored separately, were discovered in a burnt Starčevo structure at Drenovac (Filipović et al 2018); animal bone from this context was dated to the end of the 7th/start of the 6th mill BC (Porčić et al 2020). These are unique finds for the Early Neolithic in the region, as no other storage deposits of pulses, or crops in general, have been found. Renfrew (1974) notes a "significant" presence of emmer at Kakanj but does neither state the amount/density of the find (i.e. if concentration) nor the approximate age of the finds (based on the site's occupation phase), so they need not be Early Neolithic (phase Kakanj II is Late Neolithic – cf. Gimbutas 1974).

It seems that the basic crop suite was introduced at a similar time across the central and western Balkans, with the possible exception of free-threshing wheat, which looks like it reached central Bosnia some time before Serbia, perhaps taking the route along the Adriatic coast (Orton et al 2016; Vander Linden et al 2021) and then north into the continental zone. In addition to the wider distribution of free-threshing wheat from the second half of the 6th mill BC, some new crops arrived or began to be used with the emergence of the Vinča and Butmir cultures.

One of these is flax/linseed. At Jaričište 1, the seeds from a Vinča pit were dated to 5318-5206 cal BC (Marić

2013; Borojević and Sheridan submitted). Flax normally occurs in low numbers, but a deposit from a late Vinča house at Vinča-Belo Brdo contained more than 400 seeds and a sample from Pavlovac had over 50 seeds. Remains of textile and cord made of flax fibres were discovered at Opovo (Tringham et al 1992, 378) and impressions of flax fibres were recognised on pottery from Vinča (Ninčić 2016). Bitter vetch was another addition and, apparently, more common in the central Balkans, where in some cases it outnumbers other pulses. In a burnt house at Vinča-Belo Brdo, a concentration of about 1400 seeds was encountered, remaining from a bitter vetch store. Grass pea has only been recorded at a few sites and in minute quantities (a maximum of four at Belovode), perhaps because it was not as important as other pulses, or not recognised/considered a crop in its own right. Spelt wheat and rye likely had a similar "non-cultivation" status, as few of their remains have been discovered, all in BaH (in case of spelt, glume bases were reported for the two sites, offering a more secure basis for spelt identification than grains). In Serbia, only a wild form of rye is registered, from the Vinča culture layer at Gomolava.

In addition to hulled barley, naked barley is found at Late Neolithic sites; both types occur across the region but more frequently in BaH. Moreover, although generally present in small quantities, even on extensively sampled sites (e.g. only 8 grains at Drenovac), barley is more abundant in BaH. At Korića Han, over 160 naked barley grains were found within a concentration of cereals dominated by einkorn. The greater visibility of barley in the western Balkans echoes the increase in barley cultivation seen at this time (Late Neolithic) along the Adriatic coast, perhaps because it could be grown on the local, thin karstic soils (de Vareilles 2018).

9.5.2 Eneolithic and Bronze Age

Eneolithic evidence is available only for the eastern portion of the study region (Serbia). It is further limited by the small number of sites and the low number of remains per site (Bulatović and Filipović 2022). The Eneolithic layer at Gomolava is an exception, as it yielded almost 4000 crop remains, though the range of crops is comparable to that from other sites. Just like in the Neolithic, there may have been differences between the sites or successive phases of the period, perhaps reflecting changing roles of or interests in certain crops. At Bubanj, where early, middle and late Eneolithic phases were documented, a tentative observation is that emmer becomes less and lentil more frequent through time, whereas flax/linseed is present only in the early phase. At Gomolava, einkorn and naked barley are much more prominent than all the other crops. The lack or low presence of Timopheev's, spelt and free-threshing wheats could be due to the limited datasets or low identification potential, though their genuine absence from the suite of cultivars of this period cannot be excluded.

Apparently, the rise of many new cultural traditions during the Eneolithic did not add any new crops to the spectrum known from the Late Neolithic. If anything, some crops may have been (gradually) abandoned or forgotten. This is in opposition to the succeeding period – the Bronze Age. Of the ten available Bronze Age site-archives, nine come from Serbia, hence the observations apply mainly to the eastern part of the study region. Here, the great cultural diversity of the period finds strong parallels in the diverse choice of cultivars. This is consonant with the evidence of Bronze Age diversification and innovations in plant economies at the continental scale (Harding 1989; Behre 1998; Stika and Heiss 2013).

Besides the full Late Neolithic suite, the Bronze Age crop spectrum also included species that only sporadically occurred in previous periods (spelt wheat, rye and grass pea), as well as several new ones: gold-of-pleasure, *Lallemantia*, opium poppy, broomcorn millet, foxtail millet and broad bean. Much of this assortment is visible first in the early 2nd mill BC, in the Vatin culture contexts at the archaeobotanically richest and, so far, best-documented site of the region – Feudvar – from which first finds of gold-of-pleasure and *Lallemantia* were recovered, and in large quantities (Kroll 2016). Samples from the later occupation of this site, associated with the Belegiš II-Gáva culture, yielded mass finds of broomcorn millet. By the last few centuries of the 2nd mill BC, the Bronze Age crop suite included nineteen species of cereals, pulses and oil/spice/fibre plants.

In sum, both the choice of crops and the degree of their use across the region changed over time. Considering only the sites with archaeobotanical sampling, Fig. 9.4 summarises the frequency of occurrence of crops at these sites. The temporal trends may reflect fluctuating importance of different crops, though the uneven regional coverage, the low number of sites and the small size of the datasets call for caution and refraining from definite conclusions. Einkorn becomes more frequent through time; emmer displays the opposite tendency, particularly in the Bronze Age. Barley is initially widespread (though seemingly more common in the west), then dips slightly until the Bronze Age, during which hulled was more prominent than the naked variety. Free-threshing wheat is frequent in times of an expanding crop spectrum. Lentil, pea and bitter vetch occur at the majority of sites, with lentil found at more Eneolithic sites than the other two pulse species. The presence of grass pea and rye is low throughout, while spelt wheat sees an increase in frequency in the Bronze Age. Of the new crops introduced during the course of the Bronze Age, broomcorn millet is found at the majority of sites, though never at more sites than the core, original crops.

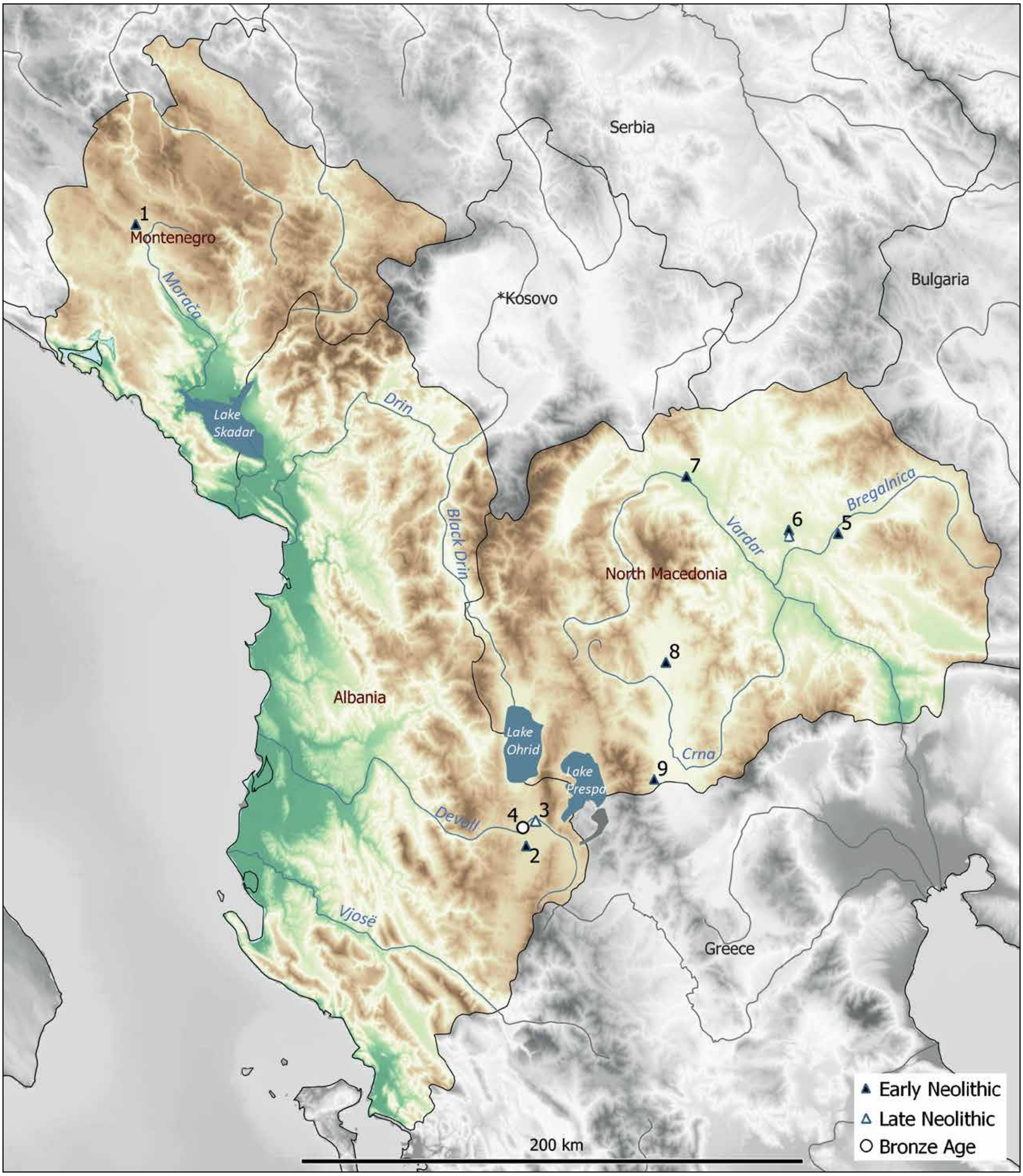

Fig. 9.5 Map of the region considered, showing location of the Neolithic to Bronze Age sites with archaeobotanical data: 1. Vrbička cave 2. Vashtëmi 3. Maliq 4. Sovjan 5. Vršnik 6. Anza 7. Tumba Madžari 8. Vrbjanska Čuka 9. Veluška Tumba.

9.6 Crops at prehistoric sites in Montenegro, Albania and North Macedonia

Whereas for this overview we remained within the political borders of our study area, the broad geographical zones we covered extend beyond these borders and into the surrounding regions. More specifically, the Sava and the Danube plains in the north are parts of the Pannonian Basin, the largest such in Europe. The Dinaric Alps in the west extend all the way along the eastern Adriatic coast and meet the Rodopes in the east. Here, the territories of Montenegro, Albania and North Macedonia belong to the northern (sub-)Mediterranean zone (Fig. 9.5). The archaeobotanical evidence from these regions could help better understand the nature of the spread of crops and crop cultivation practices, particularly in the context of the south-north (maritime-continental) bioclimatic gradient (see Ivanova et al 2018). However, there is currently very limited archaeobotanical information for these countries, unlike, for instance, for the central and north-eastern sections of the Adriatic coast (southern Croatia), where recent archaeobotanical research has enabled detailed reconstruction of prehistoric plant economies (e.g. Reed 2015, 2017).

In Montenegro, data on plant remains are currently available for only one site, and this is Vrbička cave, located 60 km inland from the Adriatic Sea. The cave was used during different periods of prehistory (Borić et al 2019). Only the layer that contained fragments of Early Neolithic Impressed Ware yielded crop remains, and these were two barley grains.

Several prehistoric sites in Albania have been sampled for archaeobotanical remains. With the exception of the Iron Age site of Grunas (Galaty et al 2013), situated in the northern mountainous area, other analysed sites are located in the south-eastern part of the country, in the similarly mountainous Korçë Basin west of the Prespa Lake (in the Maliq Lake area). They are, therefore, culturally akin to the traditions documented in continental Greece and North Macedonia. For instance, the pottery from the Early Neolithic site of Vashtëmi shows elements of the Proto-Sesklo/Sesklo style, characteristic of northern Greece. Systematic sampling and water-sieving at this site resulted in the recovery of the remains of einkorn, hulled barley, lentil, pea and grass pea. Radiocarbon dates on charcoal and cereal grains from an intact pit fill fall in the time around 6400 cal BC (Allen et al 2014; Allen 2017). At the nearby site of Maliq, a similar set of crops was identified in the Late Neolithic layers, with the addition of emmer and bitter vetch (Xhuveli and Schultze-Motel 1995).

Sites in the Korçë Basin were first excavated in the 1960s and showed that, here, the lakesides and wetland environments were occupied and exploited from prehistory; little archaeobotanical data have been made available, however. The region has in recent decades attracted attention of scholars from outside Albania and high-resolution archaeological, geomorphological and palaeoenvironmental investigations are underway (e.g. Fouache et al 2001, 2010; Allen et al 2014; Maczkowski et al 2021). Of note are the archaeobotanical results from the Bronze Age layers at the site of Sovjan, which show the presence of hulled barley, einkorn, emmer, free-threshing and spelt wheat, broomcorn and foxtail millet, rye, lentil, pea, bitter vetch, broad bean, flax and poppy (Allen 2002; Forste 2012).

Initial archaeobotanical analyses of the prehistoric material from North Macedonia were carried out in the 1960-70s for two Early Neolithic sites of the Anzabegovo-Vršnik cultural complex in the Vardar River valley: Vršnik (Hopf 1961) and Anza (also known as Anzabegovo or Barutnica) (Renfrew 1976, 1979). They yielded the remains of einkorn, emmer and free-threshing wheat, barley, lentil and pea; many of these crops were also present in the Late Neolithic layers at Anza. Recent archaeobotanical work at the 6th mill BC site of Tumba Madžari in the Skopje Basin identified emmer, naked barley, grass pea and possibly pea, and a "cache" of bitter vetch seeds within a child burial (Stojanova-Kanzurova and Rujak 2013, 71).

Most recently, archaeobotanical research has been incorporated in the archaeological excavations at two Early Neolithic sites in the Pelagonia Valley, in the western part of North Macedonia – Vrbjanska Čuka and Veluška Tumba (Antolin et al 2020). The crop spectrum recorded is comparable to that from other broadly contemporary sites in the country and includes hulled and naked barley, emmer, einkorn, lentil, pea and bitter vetch.

9.7 Conclusion

The continental part of the Balkan Peninsula is one of the earliest farming regions in Europe; its archaeobotanical evidence thus offers a particularly deep-time perspective of the plant food production on the continent. This paper focuses on the first five millennia of this activity – from the Neolithic to the end of the Bronze Age – in the central and western parts of the peninsula. The first period of food production in the region, the Early Neolithic, was characterised by the cultivation of a core set of crops which were to remain in use throughout prehistory. In the Late Neolithic, additional crops were introduced, broadening and diversifying the choice of cultivars. During the Eneolithic, the Neolithic crop suite may have contracted since evidence is lacking for some of the species, but this may be due to the limited dataset. A "boom" in the crop spectrum is evident during the Bronze Age, which also saw a re-evaluation of the existing suite; some major crops declined in importance whilst previously minor ones appear to have become more common. Continuity, diversification and innovation mark the five millennia of food production in the region.

Thanks to its geographical position, the region served as conduit for the advance of agriculture and other Neolithic practices towards central Europe. The pace and nature of this advance were determined both by cultural and natural factors and would likely have resulted in differences between early agricultural niches in the range of plant foods produced and the degree of reliance on individual or groups of crops. In our overview, inter-regional variation is apparent in the absence of grass pea in the continental zone during the Early Neolithic – a time when it seems to have been present in the sub-Mediterranean zone (e.g. at Vashtëmi). In that period too, free-threshing wheat emerged in the western Balkans but was seemingly not yet established in the central part of the peninsula. In the Late Neolithic, barley may have been more favoured in, and/or better suited to, the coastal and inland Adriatic zone. Intra-regional variation may be visible in the changeable crop spectrum when comparing Late Neolithic sites. However, a more nuanced view into these possible differences in food production observed at a regional level demands larger, systematically produced and temporally better framed datasets from under-researched parts of the region.

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Chapter 10

Strategic drinking: the shelf-life and socio-political importance of Early Iron Age west-central European beer

Joshua Driscoll

Abstract

This article examines key assumptions about the durability of ancient beer in order to investigate how the production and consumption of alcohol was entangled with social organization and political practice in early Iron Age west-central Europe. An experimental archaeological approach was used to test the terminal shelf-life of ancient-style beer stored in a variety of vessels, including modern equipment with known oxygen permeability rates, low-fired coil ceramics sealed with either beeswax or brewer's pitch, and oak barrels. The article discusses the role of archaeological, ethnographic, and historic evidence in determining likely parameters for brewing an ancient-style beer and then examines methods for testing beer's shelf-life. The results of the experiment are evaluated with reference to ethnographic and historic models that link beverage shelf-life and politically motivated feasting events. Hypotheses about Iron Age beer's entanglement with elite status are compared to archaeological data from early Iron Age west-central Europe, revealing the need to reconsider the relationship between local beverages, like beer and mead, and foreign imported Mediterranean wine as strategic resources for status display and the creation of social obligation.

Keywords: *beer, wine, mead, feasting, Early Iron Age, experimental archaeology*

10.1 Introduction

During the early Iron Age in west-central Europe (ca 800-400 BC), alcohol-fueled feasts provided a means to gain and maintain political power (Arnold 1991, 1999; Dietler 1990, 1999; Krausse 1996; Olivier 1999; Stockhammer and Fries-Knoblach 2019a, 2019b). Virtually all excavated elite graves contained vessels involved in the distribution and consumption of alcohol. Likewise, drinking vessels from important settlements reinforce the vital role played by alcohol at feasting events in non-funerary contexts. Drinking together forged social bonds and heightened the ritual drama of festivals, funerals, and other gatherings. By providing alcohol as a gift to participants, the hosts of the feast accrued social prestige, while demonstrating wealth and organizational ability. In simplified terms, the more high-quality alcohol provided by a host, the larger the group that could be gathered and the greater the prestige that could be gained. The quantity of alcohol available for distribution would have been directly related to the shelf-life of the type of beverage stored. Beverages with longer shelf-lives facilitated stockpiling reserves, while

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short shelf-life beverages had to be produced around the same time as the festival and posed a logistical challenge to obtain in large quantities (Jennings et al 2005).

Traditionally, scholars have assumed that the superior shelf-life of Mediterranean wine compared to local beverages made it a more valuable political resource compared to the presumed short shelf-life of European beer (Arnold 1999, 74; Bevan 2019, 135; Dietler 2006, 115; 2020, 123; Jennings et al 2005, 281, 286-288; Venclová 1997, 144). From this perspective, the introduction of Mediterranean wine and associated imported drinking gear into temperate Europe was a major turning point in history since it allowed elites to shift from hosting small local feasts to much larger events designed to forge bonds across a wider region (Arnold 1999; Cunliffe 2008, 315; Dietler 1990; Wells 1984, 113, 130-131). In this scenario, temperate European leaders would have become dependent upon their Mediterranean trading contacts for access to a vital, politically potent, non-local resource: wine.

Although this assumption clearly plays a major role in how scholars conceive of the relationship between Mediterranean groups and those in temperate Europe, it was never systematically tested. What if the shelf-life of Iron Age wine was not so fundamentally different from Iron Age beer? What if local beverages were actually a storable and therefore a stockpilable resource?

10.2 Brewing an ancient-style beer

To investigate this question an experimental archaeology project was designed consisting of fifteen batches of ancient-style beer stored in a variety of vessels to systematically test prevailing assumptions about the parameters of Iron Age beer shelf-life. The ancient-style beer recipe adapted for this experiment was based on archaeological data from early Iron Age Europe supplemented by historic and ethnographic sources. Six-row barley was used as the beer base following evidence from a malting kiln at the 5th c BC site of Hochdorf-Reps (Stika 1996). Six-row barley was common at Iron Age sites in west-central Europe (Fischer et al 2010).

In addition to malted six-row barley, the experimental beverage had a distilled water base to which minerals were added to approximate local water profiles in southwest Germany. The ground malted barley and water were combined in a standard infusion beer mash. The resulting sweet wort (unfermented beer) was directly transferred to the fermentation vessels without being boiled. This is a major departure from modern brewing methods which involve boiling the wort and adding hops. Hops (*Humulus lupulus*) provide the bitter flavor common to most modern beer. However, archaeological and historical evidence indicate that hops did not become a common beer ingredient until well over a millennium after the early Iron Age (Behre 1999; Unger 2004). Although two grains of hop pollen were found in a beer residue from the 6th c BC Golaseccan site of Pombia, northern Italy (Castelletti et al 2001), this scant and singular evidence was more likely due to ancient contamination (Laubenheimer 2015, 42) rather than purposeful addition (Nelson 2018). Since one of the primary justifications for boiling wort is the extraction and alteration of compounds from hops, unhopped beer did not require a boiling phase. Historical and ethnographic sources from across Europe attest to traditional brewing procedures without a boiling phase (Allen 2018; Garshol 2020; Laitinen 2019). Kornøl from Norway and Sahti from Finland are remnants of this wider "raw ale" tradition. The experimental beer was fermented with a mixed microbial culture containing two strains of *Saccharomyces cerevisiae*, two strains of *Brettanomyces,* and one each of *Lactobacillus* and *Pediococcus* (Wyeast 3278). This too, is quite different from the typical modern beer, which is fermented by a single strain of bottom-fermenting brewer's yeast (*Saccharomyces pastorianus*). Before Emil Hansen's 1883 discovery of a method to isolate single yeast strains, most beer was produced through a mixed fermentation. Lack of modern sterilization methods in prehistory and residue analyses indicate that ancient mixed fermentations involved top-fermenting brewer's yeast (*S. cerevisiae*) in combination with other yeasts, such as *Brettanomyces*, and bacteria, such as *Lactobacillus* and *Pediococcus* (Grüss 1931; 1936; Guerra-Doce 2015; Samuel 2000, 547-8, 556).[1] The batches were fermented to approximately 5% abv.

10.3 Sour style beer

When present in sufficient numbers and given time, the bacteria strains produce sour flavors like those found in traditional Gose, Berliner Weisse, or Lambic beers. Today, sour or tart flavors are found only in a few rare traditional styles or in the recent modern sour styles produced by microbreweries. In contrast, most beers made today are in the bottom-fermenting lager category and are not supposed to taste tart or sour; the development of these flavors is considered to spoil lager beer. This partly explains why many archaeologists and historians have assumed that sour beer was spoiled beer (Jennings et al

1 A recent study purporting to revive ancient fermentation microbes for physicochemical and DNA analysis suggested that some ancient fermentations may have been driven by non-*Saccharomyces* microbes (Aouizerat et al 2019). Although this study may have identified additional species involved in ancient fermentations, it is very unlikely that these fermentations were not initially driven by *S. cerevisiae.* This assertion is based on copious ethnohistoric evidence as well as the biological properties of *S. cerevisiae* (Albergaia and Arneborg 2016). It is more likely that Aouizerat et al (2019) were unable to find evidence of *S. cerevisiae* in all vessels due to taphonomic factors rather than true absence.

2005, 281; Unger 2004). They assumed that since ancient European beer was brewed without hops, which are an important part of keeping beer from turning sour, ancient beer must have gone bad very quickly (Dietler 2006, 238; 2020, 122).

However, sour-style beer was once widely popular. Historic brewing literature, especially sources from the 19th c, indicate that tart or sour-style beer was once consumed across Europe (Lacambre 1851; Pattinson 2011; Sparrow 2005). Thus far I have documented over 75 examples, including lesser known styles like historic Bière de Garde, Adambier, Cöpenicker Moll, Drogheda Ale, and Mestreechs Aajt. In some cases, surviving records even note the titratable acidity of particular samples (Pattinson 2011). The titratable acidity of beer is a key metric reflecting sour taste (Allen 2018, 36-41) that provides a quantitative means of confirming and comparing sourness between styles and through time. Most of these styles died out just before or soon after the dawn of the 20th c as artificial refrigeration and single cell isolation became more popular. A world-wide ethnographic survey of traditional brewing also reveals the importance of sour-style beer, which is found on every continent with a local brewing tradition. For example, sorghum and millet beers from across the entire African continent are typically tart or sour (Briggs et al 2004, 589-605; Lyumugabe et al 2012) as are many variants of maize beers found throughout Central and South America (Bruman 2000; Piló et al 2018). These traditions embrace the tart flavor introduced by lactic acid bacteria working alongside yeast. For most of human beer drinking history, sour-style beer has been considered good to drink.

10.4 Terminal shelf-life

If sour beer was good beer, when would a beer have been considered spoiled? The point at which all beer, cross-culturally, would be considered spoiled can be termed its terminal shelf-life. Beer's terminal shelf-life is the length of time that a beer can be kept before 1) becoming a health hazard due to pathogens or toxins or 2) turning into vinegar as a result of acetic acid bacteria. In nearly all cases, we can conclude that ancient beer would have been safe from common pathogens. Traditionally brewed beers, even those without hops or a boiling stage, are still made using processes that kill most pathogens, and the resulting beverages, especially sour styles, typically have enough alcohol and a low enough pH to be inhospitable to all common foodborne pathogens (Vriesekoop et al 2012).

The real enemy of beer is acetic acid bacteria. These bacteria use oxygen to convert alcohol into vinegar. We can expect that any ancient beer that turned to vinegar would have been considered spoiled and unfit for politically motivated feasting. Although vinegar is still a very useful product, it does not tend to engender the same conviviality as booze. Since acetic acid bacteria need oxygen to spoil beer, brewers work very hard to store their beer in a way that limits contact with air. In fact, the most important part of keeping a beer drinkable is storing it properly. This is also true of hopped beer today, since hops are not effective against gram-negative bacteria including acetic acid bacteria.

Although today's stainless-steel kegs were not available to Iron Age brewers, they did have various types of sealable containers. Recent chemical analysis supports the conclusion that large ceramic vessels were often sealed with beeswax and in some cases may have been sealed with pitch, a product made from tree resins (Rageot 2019a; 2019b). Alternatively, wooden vessels may have been used to store beer since the barrel appears to have been invented by the early Iron Age (Marlière 2014).[2]

10.5 Storing and testing an ancient-style beer

In order to test the shelf-life of ancient style beer, fifteen experimental batches were stored in containers with different oxygen permeabilities.[3] Two batches were stored in small oak barrels. Six were stored in low-fired, coil-built ceramic vessels produced in accordance with previous work on the experimental archaeology of early Iron Age ceramics by Bettina Arnold and Seth Schneider informed by Berdelis (2001). Two of these vessels were left unsealed, two were sealed with beeswax, and two were sealed with brewer's pitch made from pine resin (Fig. 10.1). Other batches were stored in modern brewing equipment with known oxygen permeabilities to establish baseline data. Two basic batches and two others with added mugwort (*Artemisia vulgaris*) were stored in 24L High Density Poly Ethylene (HDPE) buckets, two were stored in 24L glass carboys, and one was left in an open 24L HDPE bucket with no lid or airlock.

The beer was then tested for spoilage on a regular schedule that included measuring changes in specific gravity, pH, and titratable acidity along with smelling and tasting the beverage. Titratable acidity measurements were used to track whether the beer's sourness fell within the historically recorded range for sour-style beers and to indicate if the beverage was changing into vinegar. While modern scientific measurements helped to carefully

2 The origin of barrels is still unclear. The earliest potential examples have been found in 5th c northern Italy, but these presumably reflect an earlier and geographically wider tradition whose presence is unfortunately obscured by the poor archaeological survivability of wood (Marlière 2014).

3 Oxygen permeability rates for the brewing equipment considered in this study derive from Sparrow (2005:220). Note that modern brewing vessels and barrels are not permeable to their liquid contents but only to smaller molecules including oxygen, whose ingress may induce spoilage.

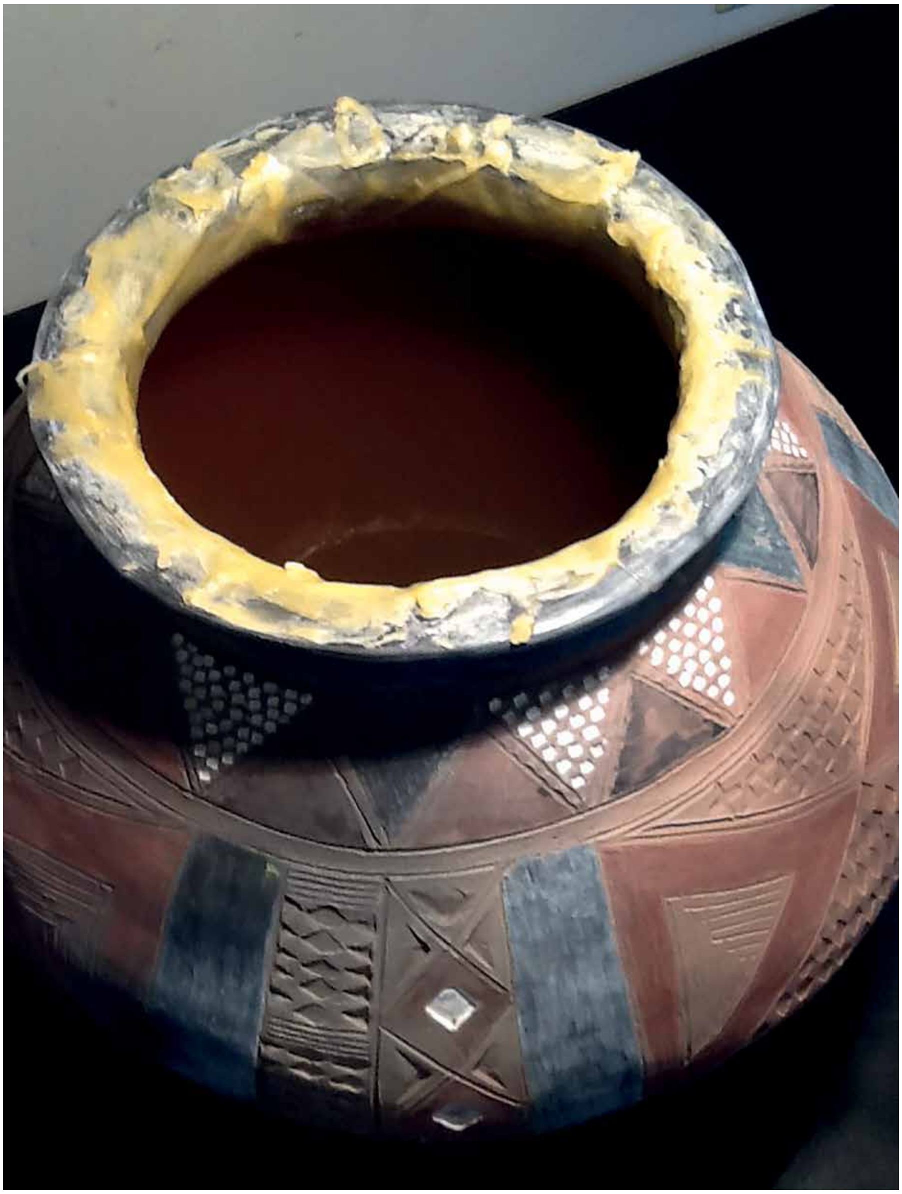

Fig. 10.1 Ceramic vessel sealed with beeswax (Photo: by author).

track changes, it turned out that simply smelling the beverage was a very effective way of determining when the change from beer to vinegar was in process. Ancient brewers would also have noticed this change easily and presumably experimented with storage methods to avoid spoilage of their valuable beer.

10.6 Experimental results

Ultimately, this experiment demonstrated that sour-style ancient beer could have been stockpiled for a very long time in the right sort of containers and under the right conditions (Table 10.1). Some of the experimental batches have not yet spoiled more than two years after brewing, and an earlier, single-batch, pilot study has not spoiled after three years. Of special interest are the two batches stored in 24L HDPE brewing buckets. One of these batches is still unspoiled 26 months after brewing. The other lasted at least 17 months, although its titratable acidy approached the upper limit of ethnohistoric attestation for Lambic and Flanders acid ale styles, which is around 1.8% titratable acidity as lactic. Table 10.2 includes titratable acidity values for selected modern sour beers to provide sourness context. The longevity of these batches is particularly striking since 24L HDPE buckets are nearly 26 times more oxygen permeable than a standard wooden wine barrel (Sparrow 2005, 220). HDPE buckets represent the worst type of modern storage vessel. If ancient style beer can be stored in these vessels, then it could have been stored for long periods in any well-sealed vessel. Of the two glass vessels, both batches are still unspoiled after 26 months.

Vessel	Age	TA% (as lactic)	pH
HDPE bucket #1	26 months	1.11	3.65
HDPE bucket #2	17 months	1.74	3.43
HDPE bucket mugwort #1	6 weeks	1.15	3.51
HDPE bucket mugwort #2	24 months	1.64	3.57
Glass Carboy #1	26 months	1.33	3.39
Glass Carboy #2	26 months	.82	3.77
Barrel #1	24 months	1.33	3.37
Barrel #2	24 months	1.10	3.47

Table 10.1 Minimum shelf-life duration with acidity values for ancient-style beer stored in different vessel types (excluding ceramic vessels).

Beer Name	Date of Analysis	TA% (as lactic)	Source
Lambic	1889	1.11	Wahl and Henius 1902:826
Timmermans Oud Gueuze	2017	1.86	Fields 2018
Verhaege Duchess de Bourgogne (Flanders Acid Ale)	2004	1.80	Sparrow 2005:104
Cöpenicker Moll	1850	1.19	Pattinson 2011:130
Berliner Weisse	1850	.85	Pattinson 2011:130
Quedlinburger Gose	1850	.85	Pattinson 2011:131
Breyhan	1850	1.29	Pattinson 2011:130
Cottbuser	1850	1.11	Pattinson 2011:130
Salt's Burton Ale	1862	1.10	Pattinson 2011:167

Table 10.2 Titratable acidity of selected historic beer styles.

Mugwort (*Artemisia vulgaris*) was added to two batches stored in 24L HDPE buckets to generate baseline data about one possible beer additive suggested to have preservative properties and implicated in ancient brews from Spain and Iron Age Germany (Stika 2010, 2011) as well as much later ethnohistorically attested beers (Cornell 2010). One batch only lasted about six weeks for unknown reasons, while the other is still unspoiled after two years. This example reminds us that beer is a living agricultural product subject to some difficult-to-pinpoint variability. Mugwort gave these batches a distinctive taste including a perceived sweetness. This reminds us that perceived taste can be quite complex not only from a culturally situated standpoint but also from the interrelation of different quantitatively measurable flavor compounds. Although cross-cultural ethnohistoric data, including titratable acidity measurements, support a common general framework for understanding the sourness of beer, we should remain cognizant of the roughness of this resolution, which may be refined through future experimental work based on emerging archaeobotanical findings concerning other likely beer ingredients or the lack thereof.

Eight batches were stored in the types of containers that would have been available during the early Iron Age. The beer stored in approximately 23L oak barrels has lasted for two years and remains unspoiled. This is a particularly significant result given the relatively small size of these barrels. Smaller barrels have a much larger surface to area ratio than large barrels. Since oxygen passes through the surface of the barrel, small barrels have a much higher exposure per volume of beer to oxygen than large barrels. Therefore, we should expect large Iron Age barrels to have fared even better than my smaller lab-sized ones (modern wine barrels typically hold around 190-230L).

The results of the batches stored in ceramic vessels proved a bit more complicated. As expected, the experimental beer spoiled quickly in the unsealed vessels, since the porous ceramic was permeable to liquid as well as oxygen. Fermenting beer seeped through the vessels during the first few days resulting in internal and external mold growth as well as rapid acetification. Unexpectedly, the samples from the wax- and pitch-sealed vessels also spoiled quickly. These results were not included in Table 10.1, because they reflect errors made during the sealing process rather than the true potential of Iron Age technologies. Subsequent examination of the vessels revealed small bubbles throughout the internal wax and pitch coatings, which compromised their integrity as water-tight seals. As a result, fermenting beer leaked from these vessels resulting in early internal and external mold growth as well as early acetification. Future experiments will address this problem by heating the vessels before the application of wax or pitch to maximize the evenness of sealant application and second coats will be applied when necessary. It is recommended that the quality of a vessel's seal is tested using distilled water before experimental use. Although achieving a proper seal might be difficult for the experimental archaeologist, expert potters would have used wax or pitch to effectively seal their vessels as attested by many historic and ethnographic examples. For example, traditional wine makers in Georgia age wine in buried clay vessels sealed with wax known as qvevri (Granik 2020, 48-65). Similarly, Portuguese Talha wine is aged in huge clay vessels sealed with a pitch mixture (Martins et al 2018). Since wine is also spoiled by acetic acid bacteria, we might reasonably conclude that traditional methods capable of sealing and preserving wine would also have worked for beer.

Although data from the batches stored in improperly sealed ceramic vessels is not generalizable to the Iron Age, the multiple instances of dramatic spoilage proved helpful in confirming the accuracy of the methods used for detecting spoilage. Spoilage as confirmed by pH, titratable acidity, and smell always corresponded to a rise in specific gravity. Although this was expected based on theoretical considerations, it had not previously been experimentally demonstrated. Ultimately the fact that batches stored in highly oxygen permeable HDPE vessels, low permeable glass vessels, and wooden barrels easily lasted over two years strongly suggests that ancient-style beer could have had a long shelf-life, not unlike imported wine (which was also affected by acetic acid bacteria as a result of exposure to oxygen).

10.7 Recontextualizing ancient alcohol

These results suggest that beer drinking temperate Europeans were not socio-technologically handicapped by their lack of access to vinicultural technology as has been commonly implied by Iron Age scholars (Dietler 2020, 123; Wells 1984, 113-115). Instead from a technical point of view, we have reason to believe that Iron Age beer could have been stockpiled as readily as Iron Age wine. This is not entirely unexpected since Pliny mentions aged beer in 1st c AD Spain (*Historia naturalis* 14.29.149). Aged beer also seems to have been known to the Roman jurists Masurius Sabinus (1st c AD) and Ulpian (3rd c AD), both recorded by Justinian (6th c AD) (*Digesta* 33.6.9). If ancient unhopped beer spoiled in a matter of days, as has been commonly assumed, then it is difficult to account for why it is considered alongside wine in litigating last wills and testaments. The jurists discuss whether cellared beer types known as *zythum*, *camum*, and *cervesia* counted as *vinum* (wine) when executing a will. The general advice was that beer should not count as *vinum*, but that if a testator considered it to be in the *vinum* category along with their cellared wine, then that testator's understanding should be honored. This passage makes little sense if the unhopped beer in question was not storable, since it would not last long enough to be distributed by the executor. Textual sources from ancient Egypt and Mesopotamia also record various examples of aged unhopped beers, suggesting that storable beer was more widely known in the ancient world than has previously been assumed (Bottéro 2004, 92; Civil et al 2008[1973], 30-1; Lutz 1922, 75-6, 82-3, 91; Neumann 1994, 331).

Ultimately the storability of beer and wine probably had less to do with the actual products and more to do with their storage containers and the subsequent treatment of those containers. In practical terms this means that locally produced and carefully stored beer might have actually had a longer shelf-life in early Iron Age temperate Europe than far-traveled imported Mediterranean wine. Wine was often stored in large sealed dolia or smaller amphorae. In the case of large dolia, especially any that were kept buried, wine would have to be transferred to a new container for shipment. Although some wine made it all the way to temperate European sites in amphorae by river or even overland (Sacchetti 2016), much was probably transferred into other vessels to facilitate overland transport. This was probably the case for wine at the Heuneburg hillfort on the Danube River in southwest Germany, where the meager remains of amphorae seem to be at odds with the abundant archaeochemical evidence for wine (Rageot et al 2019b). The fact that some wine residues came from local storage ceramics may point to another transfer event, where wine was poured from a skin or barrel into the local vessel for storage (Rageot et al 2019b). Each time fully fermented wine or beer is transferred to a new container oxygen is introduced, accelerating the spoilage process.

Furthermore, any oxygen permeable container like a barrel or most traditionally sealed ceramics will be subjected to increased gas exchange with sloshing, jostling, and temperature changes, which is why wine and beer cellars are kept at a relatively constant temperature (del Almano-Sanza and Nevares 2018; Scrimgeour et al 2015). One can image that the journey of wine from Italy or southern France into temperate Europe would include less than favorable storage conditions as amphorae were slung up and down from boats or carried along bumpy trackways by wagon exposed to the fluctuating temperatures of day and night. Contrast this to a barrel or amphora of beer peacefully ensconced in a storage facility awaiting movement only in preparation for feast day.

Future research will investigate the effects of significant temperature fluctuations on ancient-style beer and wine to complement the baseline data generated by this experiment, which kept beer stored at a relatively constant temperature between 18-20 degrees Celsius. Presumably, Iron Age Europeans would have recognized the benefits of minimizing temperature fluctuations during storage given their own empirical observations. Unfortunately, not much is known about storage facilities for products other than grain during this period. However, they likely varied based on local, traditions, and topography ranging from the use of simple above-ground, post-built structures to nearby caves to below-ground pits or cellars like those identified in early Iron Age Champagne, France (Audouze and Büchsenschütz 1991, 126-131; Peake et al 2011, 325).

Although many ancient texts valorized well-aged fine wine used in elite gift exchanges, most wine in antiquity was probably drunk within the year (Borza 1983; M. Powell 1996, 111; Thurmond 2017; Wilson 2003). This is supported by both textual sources and archaeological evidence. For the Roman period, Thurmond notes that "in every case where the size of the vineyard is known or can be estimated, it is more or less consistent with the capacity of the dolia in the *cella vinaria*" (2017, 167). In other words, wineries were typically equipped with space to hold only one year's vintage. Although many of these sources of evidence post-date the early Iron Age, it is reasonable to assume that if most wine was drunk young in the Roman period, then it was also drunk young in previous periods with even smaller-scale viticulture production levels. Therefore, we should not assume that all the wine arriving in early Iron Age temperate Europe was intended to be stockpiled. Some could have arrived already spoiled. The wine-turned-vinegar would leave the same archaeochemical signature as unspoiled wine. Other wine would have been of average to low quality especially after long-distance transport. If much of the wine in the ancient world was destined to be drunk within months rather than years, then we should also consider how strongly seasonality might affect elite access to drinkable, still alcoholic wine. I do not intend to suggest that all the wine consumed in temperate Europe was bad. Rather these considerations are meant to reframe the discussion as one in which wine is not assumed to be biochemically superior to beer. In many respects these beverages have remarkable similarities which have been obscured by their continued importance in modern discourses of power and identity themselves entangled with how we interpret the past.

A new model for understanding the place of alcohol in early Iron Age Europe requires a more complete consideration of the many variables involved in the production, transport, and storage of alcoholic beverages. It also requires a more nuanced consideration of beverage categories. For example, we know from textual and archaeological sources that "wine in antiquity" was not a homogenous entity, but included various colors, strengths, and qualities (Komar 2020; McGovern 2019; Tchernia 1986). Further variation could be imparted from the addition of honey, resin, or herbs (Garnier and Dubuis 2019). The growing number of wine residues from early Iron Age sites in Germany and France such as the Heuneburg, Mont Lassois, the Breisacher Münsterberg, and Lavau likely derive from multiple types of wine. Given the extent of contacts between elites at these sites and Mediterranean societies, especially with regard to drinking gear, it seems quite plausible that some wine residues might have come from well-aged fine wine exchanged among the powerful in a manner analogous to the Homeric elites, Medieval royalty, or contemporary contexts. We might expect that different types of wine were imported and exchanged for different purposes and audiences. It is likely that much of the larger scale wine consumption hinted at by the growing corpus of archaeological residues represents common wine. However, we should also expect some finer varieties to have been acquired or that some differences would have been socially manufactured to help perform the types of social distinction that are commonly projected by alcohol at feasting events.

Beer too was probably available in different forms (Nelson 2014). Beer could be made from barley, wheat, or millet. Only barley malt is archaeobotanically attested from early Iron Age west-central Europe. However chemical evidence for millet (miliacin) in conjunction with possible fermentation markers (bacteriohopanoids) in drinking vessels from Mont Lassois seem to confirm the production of millet beers (Rageot 2019a), which are textually attested for contemporary regions in the Balkans (Nelson 2014, 15). The existence of wheat beer is also probable given possible residue from an early Iron Age vessel found at Pfrarrholz, Germany (Hundt 1962) and extensive textual attestation from the later Iron Age in western Europe (Nelson 2014). Beer additives may also have been used to create variations with social meaning. Evidence from Hochdorf suggests the use of mugwort and carrot seed as flavorants (Stika 2010). Likewise, honey may have been added to some brews, as it appears to have been added to sweeten the wine at Lavau (Garnier and Dubuis 2019, 199).

Therefore, a new model of alcohol fueled feasting in the early Iron Age must move beyond comparisons of beer and wine as oppositional categories. Instead we should anticipate a beverage landscape in which different types of beer were used to mark social distinctions and were stockpiled in sufficient quantities for largescale display and distribution at feasting events. When wine was introduced, it was probably also available in different varieties, and based on the honeycomb recovered from the 5th c BC Lavau cauldron, wine could be further altered with local ingredients to send social messages and establish meaningful variation.

To make matters more complicated, we must also consider the use of mead for which there is strong palynological attestation from the early Iron Age. No fewer than eight graves from Germany, the Czech Republic, and Golaseccan Italy have yielded palynological evidence for mead (Kozáková et al 2016; Rossi 2011; Rösch in press). These vessels are associated with high status graves suggesting the important place of mead as a social marker. Later textual sources written in Celtic and Germanic languages help indicate the place of mead across the longue durée (Enright 1996). The relatively high value of mead evidenced by its association with high status individuals is often explained as a function of its presumed rarity in prehistory (Arnold 1999, 74; Sherratt 1997 [1987], 25; Stika 2010, 114). This hypothesis is predicated upon the assumed scarcity of honey.

However, recent residue analyses have demonstrated the widespread use of bee-products from the Neolithic onward (Roffet-Salque et al 2015). Furthermore, the rise of lost wax casting technology in the Bronze Age would have required increased bee-product exploitation as noted by J. G. D. Clark, who argued that "both honey and bees-wax were consumed on a large scale in ancient Europe" (1942, 212). The scope of wax use during the Iron

Age is demonstrated by archaeochemical evidence from Mont Lassois, where 50% out of 99 analyzed ceramics yielded evidence for beeswax (Rageot et al 2019a), and the Heuneburg, where 46% out of 133 analyzed local ceramics had evidence for beeswax (Rageot et al 2019b). Since honey is invariably collected along with wax, archaeochemical evidence for wax is also evidence for a honey collection event. Note that wax-sealed ceramics would need to be sealed repeatedly over time due to wear during use. Therefore, each wax identification represents many bee-product collection events.

It seems that honey may have been far more widely available than traditionally assumed. Even if early Iron Age people in temperate Europe did not make artificial hives, it is hard to imagine that they did not practice some sort of bee management given the long tradition for bee-product use in the area. Ethnohistoric sources suggest that forest beekeeping coupled with honey hunting can yield very large quantities of honey (Crane 1999; Galton 1971). The total number of exploitable hives is admittedly related to the size of suitable forests, although bees can also live in rock cavities. Although early Iron Age west-central Europe witnessed a relatively high level of deforestation (Fischer et al 2010), there would still have been suitable forests, especially in some areas with lower population densities, like the Black Forest (Henkner et al 2018), or at higher elevations, like the Swabian Alb. Palynological evidence suggests that Iron Age honey for a single mead brew could be collected across significant distances (Rösch 1999; in press). Therefore, we might expect that elites could import honey from areas most suitable for bee-management.

Some speculative math can help us think about how honey availability would have impacted mead production. The spectacular cauldron at Hochdorf was once filled with 350 liters of mead estimated to have been produced using 73-292kg of honey (Körber-Grohne 1985). If we assume an average log hive or tree hollow yield to be 5kg per year, then 15-59 hives would be needed to fill the cauldron.[4] At a10kg per year yield only 8-30 hives would be needed. Ethnohistoric sources indicate that this work could be accomplished by very few specialized forest beekeepers or by requiring a honey tribute from regional farmsteads.

Therefore, it seems reasonable that elites could have gained access to plenty of honey mead for largescale distribution at feasts, especially if the highest quality of mead was reserved for a few while a lower-quality honey mead was more widely distributed. This honey could have been collected via forest bee tending and honey hunting, but we should also entertain the possibility that hive beekeeping was practiced in early Iron Age temperate Europe. The lack of obvious archaeological hive remains has been overinterpreted as representing strong evidence for a lack of apiculture. However, the archaeological remains of hives should not be expected to survive in clearly identifiable forms (Crane and Graham 1985, 148). In fact, no unambiguous hives have been identified in all of ancient Egyptian archaeology despite obvious pictorial and textual evidence that they practiced beekeeping in artificial hives (Kritsky 2015). Why then should we expect clear evidence from ancient temperate Europe? It seems hard to imagine that generations of ancient forest bee-tenders never thought to cut down and bring back a tree trunk with a hive-filled hollow. In fact, possible examples of ancient upright log hives have been documented at sites such as Bronze Age Berlin-Lichterfelde, Germany (Lehmann 1965) and Neolithic Arbon Bleiche III, Switzerland (de Capitani et al 2002, 112-113). Using an experimental archaeology approach, Sonja Guber (2018) has shown that beekeeping in a replica of the Neolithic find from Arbon Bleiche is possible. These finds hint at an early tradition of hive beekeeping that is already well-documented by the 2nd c AD in northern Germany (Crane and Graham 1985). Ultimately, we know that high-quality mead was associated with elite drinkers from palynological evidence. However, this does not preclude the wider use of mead, especially varieties made from less honey that would have had a lower alcohol content and little to no residual sweetness. Although the raw material for making mead was certainly scarcer than that for beer, we need not assume that honey was prohibitively rare.

In addition, to beers, wines, and meads, there is also evidence for the combination of these categories to make mixed beverages referred to as grogs (McGovern 2009). By mixing various fermentative bases, aspiring hosts might have produced even more variation upon which to map social meaning. Given the current state of the evidence it seems reasonable to focus mainly on beer, mead, wine, the variations within these categories and their possible combinations. Other forms of alcohol made from sap or fruits may be archaeologically attested (Rageot et al 2019a) and should be kept in mind but were presumably available in small quantities less suited for competitive feasting displays. The use of alcoholic milk beverages is also less likely. However, both of these assumptions are predicated on later ethnohistoric evidence and should therefore be viewed as tentative.

4 From historic sources, Galton (1971, 28) estimates a yield of about 10.6kg and Crane (1999, 235-245) records examples ranging from 1.7-5 kg. Modern attempts at traditional forest beekeeping typically yield 10-15 kg (J. Powell 2016, 7).

10.8 Conclusion

To be clear, I am not suggesting that the early Iron Age was completely awash with booze. Rather I am arguing that the organizers of largescale feasts had the ability to access a wide range of alcoholic beverages with numerous possible subcategories. Although seasonality likely affected the availability of beverages, the ability to stockpile sufficient quantities of beer, mead, and later wine would have allowed organizers to consistently host regular large-scale events. Furthermore, hosts might have drawn on these stockpiles to quickly organize feasts for unexpected phenomena, like funeral feasts due to an unanticipated death. In cases when a death resulted in politically contentious succession, the ability to quickly mobilize a feast would have been vital for providing a venue to re-present the social order. In this model, we might expect that temperate European feast organizers had access to sufficient quantities of locally produced alcohol to host largescale events and sufficient varieties to perform social differences. Beer was a stockpilable resource with a relatively long shelf-life and mead was more readily available than previously thought, a model that accords well with the increasing focus on internal forces propelling social complexity in early Iron Age west-central Europe (Fernández-Götz and Krausse 2013). In this case, the introduction of imported Mediterranean wine should not be viewed as a major turning point based on wine's intrinsic properties but rather the introduction of yet another alcoholic beverage on which to inscribe new social meanings that was accessible through different production networks than beer and mead. This would have introduced even more socio-economic space for feast organizers to engage in the strategic decision making necessary to procure different forms of alcohol. Choices between different types of alcohol included decisions about who would be served and what types of vessels would be used for service by what methods; all of these variables would have to be navigated, giving the host a chance to show off their social acuity and their ability to mobilize sufficient resources. Recent analysis of the variability of vessel groupings from mortuary contexts also points to the fact that early Iron Age people from west-central Europe were working with a more complex vocabulary of commensality than previously acknowledged (Arnold 2019). Therefore, as Arnold (2019) notes, we should expect more surprises and be prepared to regularly reevaluate our models as the study of Iron Age alcohol continues to evolve.

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Chapter 11

Cereals and cereal-based products from Tiel Medel, an Early Neolithic Swifterbant site in the Netherlands

Lucy Kubiak-Martens

Abstract

This contribution focuses on cereals and cereal-based products from one of the most recently excavated Swifterbant culture sites in the Netherlands, Tiel Medel-De Roeskamp. The site dates to the Early Neolithic, and is associated with the classic phase of the Swifterbant culture (ca 4300-4000 cal BC). Large assemblages of plant macroremains from Medel were studied, including cereals and cereal-based products and wild plant foods. This is the first time that the spectrum of cereals from a Swifterbant site yielded the remains of einkorn and tetraploid naked wheat in addition to emmer and naked barley. This work addresses the economic and dietary aspects associated with the introduction of cereals into the Swifterbant culture, in particular the routes of entry of tetraploid naked wheat, cereal cultivation and processing, and the transformation of cereal grain to food. The contribution presents the results of the methodology based on the integration of stereomicroscope and scanning electron microscopy.

Keywords: *Neolithic, northwestern Europe, Swifterbant culture, tetraploid free threshing wheat, cereal-based products, SEM microscope*

11.1 Introduction

Archaeological sites of the Swifterbant culture (ca 5000-3500 cal BC) are found in wetlands between the Scheldt valley in Belgium and the Weser valley in Lower Saxony, Germany (Raemaekers 1999; Amkreutz 2013). They are often located on sandy outcrops, river dunes and levees. In the Netherlands, the Swifterbant sites are concentrated in two main areas. One is in the western part of the Rhine-Meuse River delta with sites located on the river dunes, and the other is in the northcentral part of the country, in the province of Flevoland with sites located on natural small levees and river dunes in the creek landscape in the Swifterbant area. The Medel site is situated on a small sandy clay levee, along one of the branches of a channel network of the Rhine-Meuse alluvial valley system in the province Gelderland, in the middle of the Netherlands.

The Swifterbant groups (also termed the Swifterbant culture) emerged as hunter-gatherers and later went through a long neolithisation process, which started with the introduction of pottery (ca 5000 cal BC), was followed by the adoption of domestic animals (ca 4700 cal BC), and later included the adoption of cereal cultivation (ca 4300 cal BC). Within the wetland environment, a subsistence model developed, described as an

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Sample number	Feature number	Context	14C material	Laboratory code	Date in 14C years BP	Calibrated age in calendar years BC
V413	71	occupation layer, south	charred: *Corylus avellana*	Beta-391218	5310±30	4235-4000
V670	71	occupation layer, south	charred: *Corylus avellana*-nut-shell 2x	Beta-391220	5310±30	4225-3985
V671	71	occupation layer, south	charred: *Corylus avellana*-nut-shell 2x	Beta-391221	5200±30	4045-3965
V685	71	occupation layer, south	charred: *Corylus avellana*-nut-shell 1x	Beta-391222	5360±30	4315-4050
8136	99	gully, trench 36	charred: *Corylus avellana*-nut-shell 1x	GrM-17651	5265±30	4230-3987
8408	95	gully, trench 42	charred: *Corylus avellana*-nut-shell 1x	GrM-17652	5005±30	3940-3704
17821	3734	hearth pit, north	charred: cereal-based product 1 frg	GrM-17843	5350±30	4322-4053
8159	1682	pit, south	un-charred: *Carex hirta* 14x, *Urtica dioica* 8x, *Chenopodium polyspermum* 4x, *Glechoma hederacea* 3x, *Chenopodium album* 3x, *Sambucus nigra* 1 frg	GrM-17844	5260±30	4228-3984
7708	95	gully, trench 28	charred: *Hordeum vulgare* var. *nudum*- grain 2x	GrM-17963	5295±30	4234-4041
V15998	69	occupation layer, north	charred: *Triticum dicoccon* – grain 4 frg, spiklet forks 2x	GrM-22817	5320±24	4245-4050
V7366	1312	pit, trench 21, south	charred: *Hordeum vulgare*-grain 2x	GrM-22831	5311±26	4241-4049
V8111	1666	pit cluster, south	charred: Cerealia-grain 4 frg	GrM-22818	5280±24	4233-3994
V15355	2848	house 1, south	charred: *Triticum* cf. *dicoccum*-grain 1x	GrM-22820	5282±29	4236-3992
V17315	3532	house 1, south	charred: Cerealia-grain 2 frg	GrM-23276	5305±29	4243-4046
V9853	2604	house 11, south	charred: *Corylus avellana*-nut-shell 15x, *Triticum dicoccum*- glume base 1x	GrM-23277	5308±29	4245-4046
V8055	1496	house 20, south	charred: *Corylus avellana*-nut shel 3x	GrM-22834	5300±27	4240-4045
V6949	71	occupation layer, north	charred: *Triticum durum*-rachis internodes 12x	GrM-22821	5343±24	4319-4053
V6515	836	house 20, south	charcoal: *Alnus* 2x, twig (deciduous wood, not oak) 1x	GrM-22949	5250±27	4227-3979
V5718	358	gully	charred: *Triticum dicoccum*-grain 2x, spiklet forks 3x, glume base 3x	GrM-22950	5331±27	4314-4051
V16212	2786	pit, north	charred: *Triticum monococcum*-grain 3x	GrM-23372	5337±27	4318-4052
V7684	93	gully, trench 30	charred: *Corylus avellana*-nut-shell 1x	GrM-23373	5329±27	4313-4051
V17281	3290	pit, south	charred: *Corylus avellana*-nut-shell 3x	GrM-23374	5350±27	4323-4054
V6997	70	occupation layer, trench 14, north	charcoal: *Pyrus/Malus/Crataegus* 1x	GrM-24347	5388±29	4336-4064
V15233	64	occupation layer	charred: *Corylus avellana*-nut-shell 2x	GrM-24348	5325±28	4309-4050
V9791	2593	post-hole, house 11, south	charcoal: *Alnus* 4x	GrM-24356	5327±29	4313-4050

Table 11.1 Radiocarbon dates obtained on botanical macroremains, associated with the Swifterbant occupation at Tiel Medel.

extended broad spectrum economy in which the gathering of wild plant foods, fishing, and hunting would be combined with animal farming and cereal cultivation (Louwe Kooijmans 1993, 2003; Raemaekers 1999, 2003). The neolithisation of the Swifterbant culture is proposed as a process, which evolved from contact with the descendants of the Linear Band Pottery (LBK) culture in adjacent southern and eastern areas. At Medel, which is dated to the classic phase of the Swifterbant culture (see Table 11.1), the Neolithic elements (ceramic, stone artifact imports, and house plans) all point to contact with the Rössen/Bischheim/Michelsberg tradition of the German Rhineland (ten Anscher and Knippenberg 2020). All of the Swifterbant sites from the classic phase of this culture (ca 4300-4000 cal BC) which have been studied until now yielded the remains of naked barley (*Hordeum vulgare* var. *nudum*) and emmer wheat (*Triticum dicoccum*), which were long considered a standard package of the Swifterbant culture (van Zeist and Palfenier-Vegter 1981; Cappers and Raemaekers 2008). The interpretation of the cereals from the Swifterbant sites has received much attention over the years. The main question has been whether the Swifterbant people produced their cereal crops or if these were brought to the wetland sites from elsewhere (Cappers and Raemaekers 2008). The identification of a tilled layer on the clayey levee at the Swifterbant-S4 site and the reinterpretation of observations from two other sites in the area (S2 and S3) indicated that tillage and crop production formed a regular part of the Swifterbant subsistence during the Early Neolithic (Huisman et al 2009; Huisman and Raemaekers 2014). This study aims to better understand the role of cereals in the Swifterbant

Fig. 11.1 a Charred rachis remains of tetraploid free threshing wheat (a), and charred grains of most likely tetraploid free threshing wheat (b) from Tiel Medel (sample V6949), dated to the Swifterbant use of the site (photos: M. van Waijjen).

subsistence by using archaeobotanical data. For that reason, special attention will be paid to cereals and cereal-based foods. Different approaches are used, including the application of the SEM microscope, to better understand how cereals were processed and consumed. The detailed information about the sampling strategy, methodology and the archaeobotanical results as a whole are to be found in the monograph of the site (Kubiak-Martens, in prep)

11.2 Cereal cultivation

11.2.1 The cereals at Medel

Charred remains of four cereals were found at Medel: emmer, einkorn (*Triticum monococcum*), the tetraploid variety of naked wheat (*Triticum durum/turgidum*) and naked barley. When observing the total number of charred cereal remains found at the site, emmer dominates the assemblage with 725 grains and nearly a thousand grain fragments. Emmer was followed by naked barley with 608 grains and a few dozen grain fragments. Chaff remains of barley (rachis internodes) were also present in cereal assemblages. Einkorn is represented by 67 grains and a few dozen grain fragments. Both emmer and einkorn grains were accompanied by numerous chaff remains, including glume bases, spikelet forks and rachis internodes. The identification of tetraploid naked wheat, *Triticum durum/turgidum* was confirmed by the presence of a diagnostic for this cereal, rachis segments. The rachis segments of tetraploid naked wheat reveal characteristic thickenings (swellings) under the glume base (below the glume insertion) and the maximum width is observed in the upper part of the rachis segments (Fig. 11.1a). They also have a very distinct papilla located between the glume insertion.[1] In total, 75 charred rachis segments were identified as belonging to tetraploid naked wheat, most likely durum wheat (*Triticum durum*). A dozen of grains of free threshing wheat found in Medel most likely also belong to tetraploid naked wheat (Fig. 11.1b). All the rachis remains and the grains were found in one sample (V6949, recovered from occupation layer 71) in the northern zone of the site. A series of rachis remains of tetraploid free threshing wheat provided the ^{14}C date of 4319-4053cal BC (5343±24BP).[2] There is no archaeobotanical evidence at Medel for the cultivation or use of pulses or oil plants.

When we compare the absolute numbers of emmer and barley grains there is no clear domination of either cereal. Also, the frequency of occurrences of emmer and barley grains in the macroremains samples is comparable. It seems that at Medel there was likely a balance in the use/cultivation of emmer (accompanied by einkorn) and barley rather than a dominance of one cereal over the other. The Medel cereal assemblage is somewhat different from those obtained from other Swifterbant sites in the Netherlands. At Swifterbant-S3, the high frequencies and the abundant occurrences of naked barley (nearly 2000 grains) in the samples, when compared with only small numbers of emmer, suggest that barley was by far the dominant cereal (Van Zeist and Palfenier-Vegter 1981).

1 Diagnostic features published by Hillman 2001.
2 GrM-22821. Radiocarbon calibration according to OxCal program, version 4.4.

The absolute numbers and frequencies of cereal grains recovered from the Swifterbant-S4 site also point to the dominance of naked barley over emmer (Schepers and Bottema-Mac Gillavry 2020).

In addition to cereals, a wide range of wild edible plants was well represented in the charred macroremains assemblages from Medel. Charred hazelnut (*Corylus avellana*) shells were particularly abundant at the site (over 5000 fragments). Numerous charred remains of crab apple (*Malus sylvestris*) were also found at the site. The most spectacular find was the concentration of nearly 250 apple remains found in one of the postholes (V6803) in the northern zone, represented by apple fruit parenchyma, fragments of endocarp, seeds and calyxes. Hazelnuts and crab apples were accompanied by other food plants, including hawthorn (*Crataegus monogyna*), water chestnut (*Trapa natans*) and acorn (*Quercus*).

11.2.2 New cereal – tetraploid free threshing wheat in Swifterbant subsistence – possible routes of entry

The tetraploid free threshing wheat was not known until now from the Swifterbant sites in the Netherlands. Therefore, the presence of this cereal at Medel is of particular interest. The free threshing wheats, either with the tetraploid or hexaploid genomic constitution, are rarely found in prehistoric sites in the Netherlands. The earlier finds had included a single rachis internode of *Triticum durum* from Maastricht-Vogelzang, dated to the early Michelsberg culture (4400-3600 cal BC). At this site, a few dozen grains of free threshing wheat, either hexaploid or tetraploid (*Triticum aestivum/durum*), were also found (Bakels 2008). Hundreds of rachis internodes and grains, defined as *Triticum aestivum/durum,* are also known from the Maastricht-Randwijck site, dated to the Rössen culture (4900-4200 cal BC) (Bakels 1990).

The question is: from where did the Swifterbant farmers at Medel adopt their tetraploid naked wheat?

The tetraploid naked wheat entered central Europe in the Middle Neolithic. The main cultivated species of tetraploid free threshing wheat was most likely durum wheat (*Triticum durum*) (Bakels 2012). Different scenarios are being proposed for the origin and diffusion of tetraploid naked wheat. A compilation of finds of free threshing wheat with a tetraploid genomic constitution shows the southwestern distribution of this species (Kirleis and Fischer 2014). Jacomet and Schlichthele (1983) and Jacomet (2007) suggested the origin of tetraploid naked wheat in the western Mediterranean, with the Early Neolithic Cardial groups of the Iberian Peninsula. Kreuz et al (2014) suggested that during the 5th mill BC tetraploid naked wheat may have been distributed as far as the Paris basin in northern France, and from there to the Bischheim and Michelsberg areas in the German Rhineland. Alternative pathways of entry into Central Europe might have run through the Rhône valley or Alpine Rhine valley. In Central Europe, the western Mediterranean tetraploid free threshing wheat is a late arrival in the mid-5th mill BC (Kirleis and Fischer 2014; Kreuz et al 2014). Kreuz et al (2014) also suggested that Bischheim and/or its cultural roots could have been “a catalyser for the agricultural adoption” of tetraploid naked wheat by the Egolzwil lakeshore settlers of the northern Alpine foreland (in Western Switzerland), where tetraploid naked wheat and oil plants have been found regularly from the second half of the 5th mill cal BC onwards.

The tetraploid free threshing wheat was a significant component of the crop spectrum of the Bischheim and Michelsberg groups (Kreuz et al 2014; Kirleis and Fischer 2014). The cereals from preceding Rössen culture, however, are significantly different. Here, the hexaploid free threshing wheat and the naked barley are the main crops alongside the hulled wheats, einkorn, and emmer (Bakels 2009). It is not clear whether the Rössen farmers cultivated both tetraploid and hexaploid naked wheats (Kirleis and Fischer 2014). The Bischheim culture, which is in part contemporaneous with the Swifterbant occupation at Medel, had a diverse spectrum of cultivated plants. In addition to emmer, einkorn, hexaploid and tetraploid naked wheat (*Triticum aestivum* and *Triticum durum/turgidum*), and naked barley, the farmers from the Rhineland Bischheim settlement near Jüchen Garzweiler (4350-4250 cal BC) cultivated lentil, pea, poppy (*Papaver somniferum* subsp. *setigerum*) and flax (Arora 2004; Arora and Zerl 2004). At several sites of the Bischheim group, tetraploid free threshing wheat occurred alongside hexaploid wheat (Bakels 2009; Kirleis and Fischer 2014).

It seems that the Swifterbant farmers from Medel would have introduced the tetraploid naked wheat either from the southeast, by direct contact with the Bischheim zone, or from the south through contact with the early Flemish Michelsberg farmers who also cultivated tetraploid naked wheat, *Triticum durum/turgidum* (Vanmontfort et al 2002). Tetraploid free threshing wheat could not have been introduced from the North European Plain. Even though *Triticum durum/turgidum* was presumably grown in the north in the Early Neolithic by the Funnel Beaker farmers alongside emmer and naked barley, its introduction to this region might have occurred as late as 3650 cal BC (Kirleis and Fischer 2014; Kirleis 2019).

11.2.3 The question of local cereal cultivation

Evidence for local cereal cultivation may be available through the identification of early stages of crop processing. This was demonstrated at Medel by the presence of chaff remains, especially of free threshing cereals, including the rachis remains of naked barley and free threshing tetraploid wheat. The presence of archaeological remains, including sickles with gloss and quern stones (ten Anscher and Knippenberg 2020), additionally indicates that cereals were grown locally and were processed at Medel.

Some evidence of local cultivation might be provided by assemblages of arable weeds harvested with the crops and incorporated with them into archaeological records (see Bogaard 2005). The complex ecological interpretations of weed species, however, often make it difficult to distinguish between arable weeds and ruderals. For the Medel assemblage, we assume that charred seeds of typical ruderal plants found in association with cereal remains are likely to have found their way into the settlement along with the crops and can be considered arable weeds (see Hillman 1984). This group would have included charred seed remains of *Solanum nigrum, Persicaria maculosa, Stellaria media, Galium aparine, Fallopia convolvulus, Atriplex patula/prostrata, Chenopodium album* and *Vicia hirsuta/tetrasperma*. Yet another weed that has adapted well to cereal fields or may have even been cultivated as a crop is a grass species: rye brome (*Bromus secalinus*) (Bakels 1981). Even though represented only by small numbers, field/rye brome (*Bromus arvensis/secalinus*) was the most frequently recorded in the Medel weed assemblage. The striking feature of the weed assemblage at Medel is that even though the diversity of species is reasonable, the quantities of the remains are very low. One single seed is often the sole representative of a species. Similar to Medel, the charred remains of potential arable weeds are also rare among the archaeobotanical finds from the Bischheim and Michelsberg sites (Arora and Zerl 2004; Kreuz et al 2014).

When we look at Medel, the extremely low numbers of weeds do not change the fact that the potential arable weeds are annuals of moderately nutrient-rich to nutrient-rich soils and therefore consistent with small-scale intensive cultivation. The type of agriculture practiced at Medel may have resembled one of the models proposed for Neolithic farming in central and southeast Europe, referred to as *intensive or garden cultivation* integrated with small-scale animal husbandry (Bogaard 2005). In this model, the term *intensive or garden cultivation* is used to indicate the small size of the cultivated fields. Crop cultivation in this system is relatively high-yielding due to the high input of labour (weeding and tillage or manuring), and is small-scale, within the labour capacity of a household rather than extended family groups (Van der Veen 2005). At Medel, small plots of emmer (likely accompanied by einkorn) and plots of barley would have been located on elevated levees, near the houses.

Concerning the frequency and number of the remains, cereals (predominantly emmer and barley) were second in their totals after finds of hazelnuts throughout the site. These frequent and abundant finds of cereals suggest that emmer (accompanied by einkorn) and barley would have been a regular and possibly substantial component of the Swifterbant diet at Medel. The presence of durum wheat is rather intriguing. In principle, the chaff of durum wheat, which is a free threshing cereal, would speak in favour of local cultivation. However, if durum wheat was grown in Medel, it should have occurred more frequently in the samples, unless it was only grown as a small addition to emmer, naked barley and einkorn.

11.3. Processing of cereals

11.3.1 The bread-like products from Medel

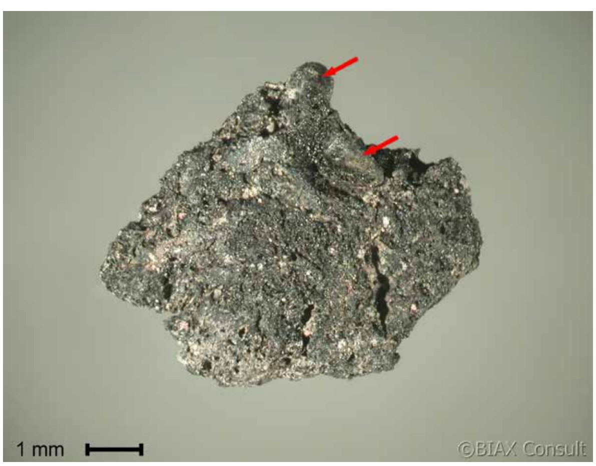
Large amounts of cereal grains and chaff remains found at the site are clear evidence of their (culinary) processing. Of great importance are the finds of cereal-based products found at the site, which revealed one of the forms in which the cereals were consumed. In total, 14 lumps of irregularly-shaped amorphous objects were recovered from various contexts, including occupation layers, postholes and hearths (Table 11.2). The lumps were briefly examined under the binocular incident light microscope at magnifications of 6x to 50x. In total, 8 charred lumps of amorphous objects which showed inclusions of cereal tissues were selected for SEM microscopy to study their composition and the internal microstructure to determine the processing and cooking method used for their preparation. The examinations presented here were carried out at the SEM laboratory of the Naturalis Biodiversity Center in Leiden.

Under binocular microscopy, some of the lumps revealed the presence of grain fragments (ca 1 mm in size) embedded in otherwise amorphous, porous matrices (Fig. 11.2 a-b). Under the SEM, they all revealed the presence of cereal components in their internal microstructure- indicating beyond any doubt that these are cereal-based products. The cereal tissues most frequently identified in the lumps were the tissues of the grain, including the aleurone layer and, occasionally, also the transverse cell layer of the pericarp. In cereal grain, the aleurone layer encloses the outer surface of the starchy endosperm. The aleurone cells store the grain's main protein content, and the structure of the aleurone layer is diagnostic for certain cereal species. In all cereals cultivated in prehistoric Europe (including wheats, oats, millets and rye), the aleurone layer is one cell thick. The well-known exception is barley, in which multi-layered aleurone develops (Körber-Grohne and Piening 1980; Hahn and Michaelsen 1996).

In 6 out of the 8 lumps of processed food from Medel, patches of single-layered aleurone tissue were identified, suggesting that likely grains of emmer/einkorn/durum wheat (*Triticum* spp.) were the main component of these charred lumps (Fig. 11.3a-d). Particles of the transverse cell layer preserved in some of the lumps further suggest

sample nr	trench	feature nr	context	Cereal product
7723	29	95	occupation layer	cereal-based product, 3 fragments
7729	29	95	occupation layer	cereal-based product, 1fragment
8224	38	1734	post hole	emmer/einkorn-based product, 1fragment: SEM single-layered aleurone tissue, transverse cells with the length between 90 and 100µ
9081	44	71	occupation layer	cereal-based product, 1fragment
15560	46	71	occupation layer	cereal-based product, 1fragment
8416	42	95	occupation layer	emmer/einkorn-based products, 4 fragments: SEM single-layered aleurone tissue, transverse cells with the length between 90 and 100µ; also chaff particles of palea or lemma from emmer or einkorn embedded in the matrix
15108	45	2693	post hole	barley-based product, 1fragment: SEM multi-layered aleurone tissue, transverse cell layer with smooth and thin-walled cells
17752	71	3733	hearth pit	emmer/einkorn-based product, 1fragment: SEM single-layered aleurone tissue; also chaff particles of palea or lemma from emmer or einkorn embedded in the matrix
17821	71	3734	hearth pit	barley-based product, 1fragment: SEM multi-layered aleurone tissue, transverse cell layer with smooth and thin-walled cells. Radiocarbon dated to 4322-4053 cal BC (GrM-17843, 5350±30BP)
5567	4	71	occupation layer	grain fragments (3x) with bulging edges, probably emmer/einkorn
6713	13	862	post hole	grain fragment (1x) with bulging edges, probably emmer/einkorn
7101	18	1160	post hole	grain fragments (2x) with bulging edges, probably emmer/einkorn
7370	21	1312	gully	grain fragments (3x) with bulging edges, probably emmer/einkorn
8195	36	1682	gully	grain fragments (5x) with bulging edges, probably emmer/einkorn
16155	46	2991	gully	grain fragments (13x) with bulging edges, probably emmer/einkorn and barley

Table 11.2 Cereal-based products from Tiel Medel dated to the Swifterbant occupation of the site.



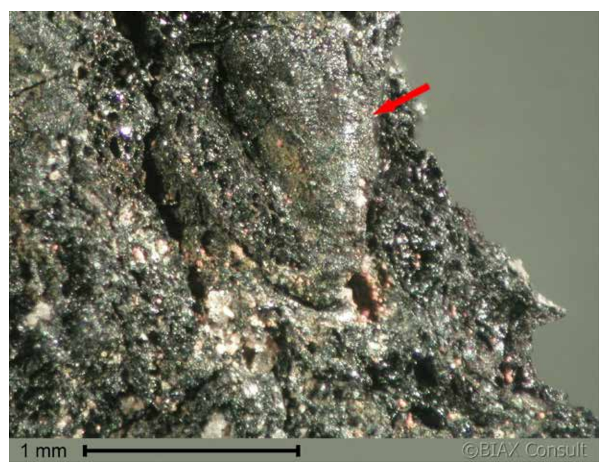


Fig. 11.2 A lump of cereal-based product from Tiel Medel, sample V17752/S3733, overview (a), and detail (b). The arrows indicate grain fragments, ca 1mm in size (photos: M. van Waijjen).

that either emmer or einkorn grains were used. One of the lumps also contained chaff particles of either palea or lemma from emmer or einkorn embedded in the matrix.

In two charred lumps patches of multi-layered aleurone tissue were identified (Fig. 11.4 a-d). They were accompanied by remains of the transverse cell layer with the characteristic smooth and thin-walled cells. Both the multi-layered aleurone tissue and the appearance of the transverse cell layer indicate that barley grain was used in the preparation of these cereal-based products.

The particles of cereal grain tissues embedded in otherwise featureless matrices of all the studied lumps of processed food were usually between 600µm and 800 µm in diameter. This would suggest that the grain went through the process of grinding or crushing and was processed into a mixture of particles, comparable to those of modern semolina (300-1000µm) and fine flour (<300 µm) (Heiss et al 2017). This can be interpreted as the (intentional) mixture of flour and incompletely/roughly ground grain. The mixture would have been used to make a bread-like product. Characteristic for all of the studied

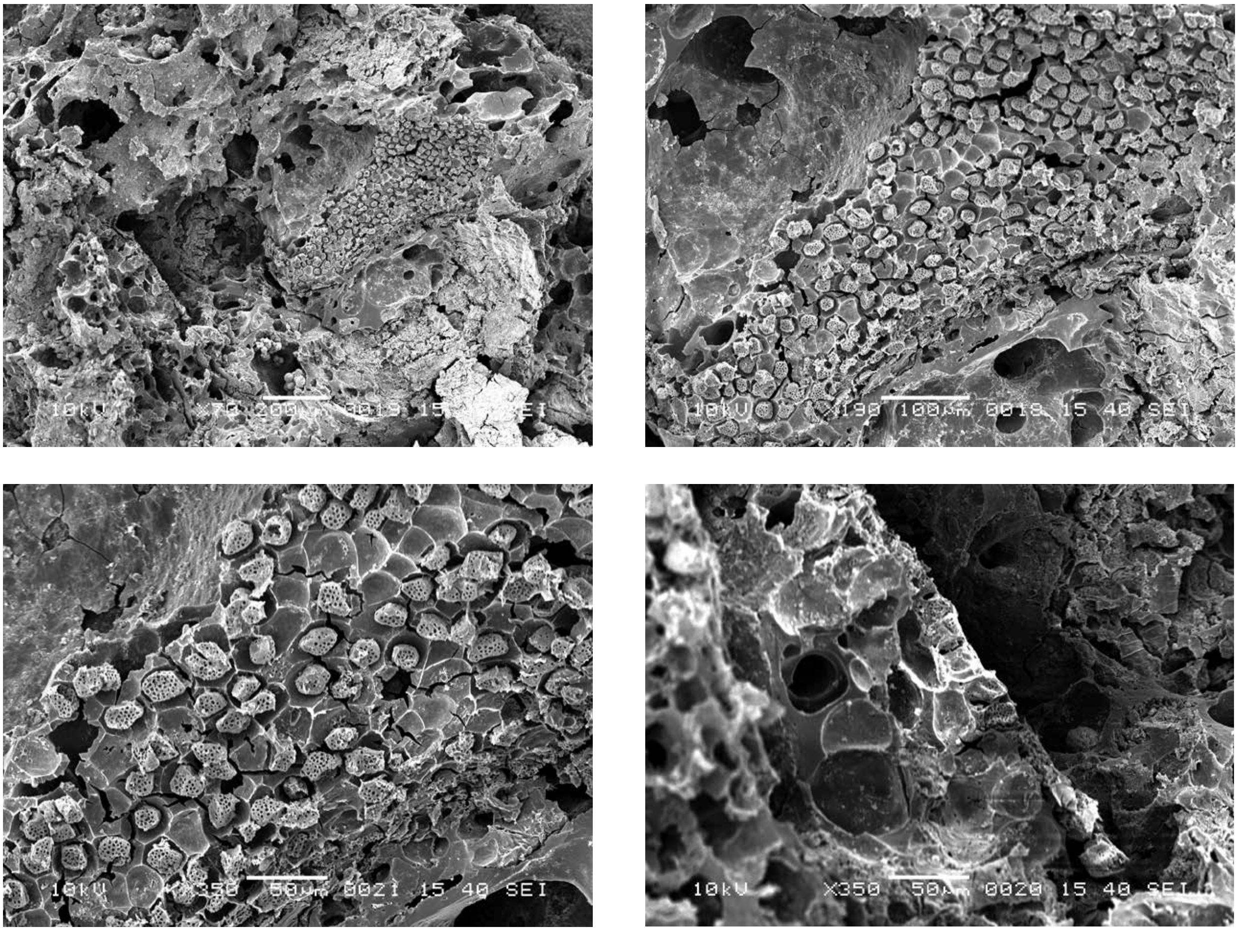


Fig. 11.3 SEM images showing the internal microstructure of Fig. 11.2, showing areas with aleurone tissue (a), single-layered aleurone tissue in the lateral view, detail (b & c) and in transverse view (d) as observed in *Triticum* spp (photos: L. Kubiak-Martens).

lumps, both those made of emmer and barley, were regularly distributed voids (air or gas bubbles) (observed in Fig. 11.3a-b and 11.4a-b). The voids were measured to evaluate the possible leavening of the dough. The air bubbles were small in size, usually between 50 and 100 µm and occasionally 200µm in diameter. As such, they would indicate a poor or short leavening process, resulting in a flatbread (see Heiss et al 2015).

The lumps of processed cereal food found at Medel can thus be classified as derived from unleavened or flatbread-like products, as only small pores were observed in the bread dough. Emmer/einkorn or barley grains were used. There is no evidence that the different cereals were mixed. Also, no evidence of admixtures of other components could be recognized in the SEM analysis, suggesting that the bread-like products were exclusively cereal-based.

Even though the finds of bread or bread-like remains from the European Neolithic are rare, still they show that bread-making has been a part of the European tradition of food preparation since the Early-Middle Neolithic. Among the early bread-like finds, those from Medel and those, for example, from the Late Neolithic Swiss lakeshore dwellings, are unique and of particular significance when considering the detailed examination of their internal microstructure. Some of the best studied examples are the bread-like objects from the lakeshore settlement Parkhaus Opéra, near the current shoreline of Lake Zürich. They were classified as flatbread and composed of grain chunks and ground flour of barley and a mixture of barley and wheat (Heiss et al 2017). This also shows that the finds of bread-like products from Medel are consistent with finds of unleavened bread from other Neolithic sites in Europe.

It seems that the archaeological finds of round, clay plates from Neolithic sites, often referred to as *baking plates* may actually be associated with bread preparation. The remains of *baking plates* made of pottery are known from the Bischheim site at Bischoffsheim in northeastern France (Jeunesse et al 2004) and the Michelsberg site at Maastricht-Klinkers in the province of Limburg, in the Netherlands (Schreurs 1992). At Medel, no archaeological

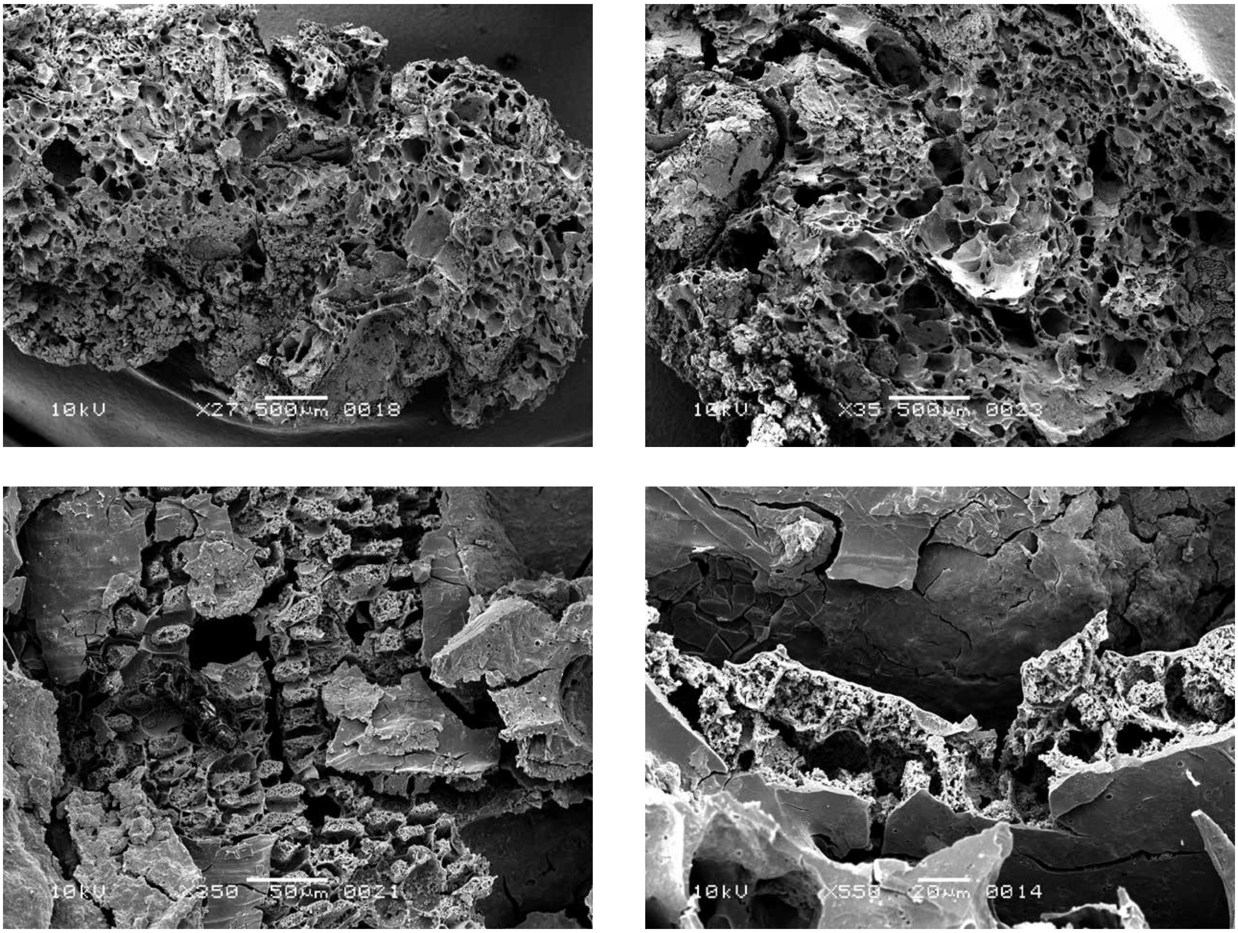


Fig. 11.4 SEM of cereal-based product from Tiel Medel, sample V17821/S3734, ^{14}C dated to 4324-4053 cal BC (5350±30 BP), showing internal microstructure with regularly distributed air bubbles, 50 to 200μm (a-b), also grain particle 1mm in size (in b), aleurone tissue in lateral view (c) and multicellular aleurone layer in transverse section (d), indicating barley (photos: L. Kubiak-Martens).

Fig. 11.5 Experimental baking of bread on a pottery baking plate. The baking plate made of pottery (or stone) would have been placed in the hot ashes of a fire (photo: S. Bloo).

remains of pottery plates were found, but one of the stone artefacts can possibly be interpreted as a stone baking plate (ten Anscher and Knippenberg 2020). A baking plate made either of pottery or stone (see also this volume Bekiaris et al, Chapter 19) would have been heated by the fire and then the dough would have been spread on it, as demonstrated during the experimental practice (Fig. 11.5).

11.3.2 Fragmented grains

At Medel, a series of fragmented cereal grains with characteristic bulging on the fracture surface were found in postholes and among the refuse/domestic waste which accumulated in the Swifterbant gully and the occupation layer in the southern zone of the site (see Table 11.2**)**.

The bulging surface was smooth and shiny (glassy) on most of the specimens (Fig. 11.6). The fragmented grains ranged in size between 1.5 and 2.5 mm. It seems that the fragmented grains were derived from various cereals, including barley and emmer/einkorn. This phenomenon in the preservation of archaeological cereal grain remains was first observed and described by Knörzer in 1981. A much appreciated experimental work investigating the various methods of preparation of cereal meals and how these various methods are reflected in archaeological material was published by Valamoti and her colleagues (Valamoti 2002; Valamoti et al 2008; Valamoti et al 2019; Valamoti et al 2021). Fragmented grains such as those found at Medel may correspond to some method of cereal processing and preparation of food. They show longitudinal and transversal fracture surfaces. The bulging on the fracture surface suggests fragmentation of the grains before charring. The shiny appearance of the bulging surfaces of the grain fragments indicates that they were exposed to some deliberate processing method that involved the crushing or grinding of the grains and possibly subsequent heating or boiling in liquid, likely in water. Even though the process of the gelatinisation of the grains' starchy endosperm is evident (glassy bulging endosperm), it is difficult to specify whether it was generated as part of the grains' pre-treatment (for example, soaking or parboiling), or during the cooking of cracked grains in liquid.

The crushing or grinding of the grain could have been intended to produce porridges or meals made of cracked grains. The loose fragments of grains with shiny bulging endosperm could represent cracked grains that escaped the cooking pots and became charred in cooking fires. Similar finds of possible crushed/ground cereal grains are found more often at Neolithic sites in the Netherlands, for example, at the Middle Neolithic Well Aijen. At this site, they were found in a posthole context and ^{14}C dated to 3647-3525 cal BC (4801±27 BP). Here also, the characteristic bulging was observed on the fracture surface of the grain fragments, suggesting some method of grain processing for food (Kubiak-Martens 2018).

11.3.3 Organic residues – cereals in Swifterbant pots

The cooking of cereal-based meals in Swifterbant pots is well documented through the study of food residues encrusted on pottery sherds, conducted at Medel (Kubiak-Martens and Oudemans, in prep) and other Swifterbant sites (Raemaekers et al 2013). The broken grains such as those found at Medel suggest that the cereals would have been ground or crushed into a type of grist before cooking. As such, they were likely intended to be cooked in ceramic vessels, either as porridge-like food or some kind of bulgur.

In general, when food residues are preserved, they are found firmly attached to either the interior or to the exterior surface of the pottery sherds, and, as such, they are considered to reflect the original vessel contents (Fig. 11.7). The use of the Scanning Electron Microscope (SEM) proved to be an essential method for studying the internal microstructure of these food residues. The SEM allows the examination and identification of the plant particles that survived the processes of food preparation and cooking and that are now embedded in residue matrices. SEM analysis, however, should always be performed together with chemical analysis, either the chemical direct temperature-resolved mass spectrometry (DTMS) or molecular and isotopic analysis of lipids, as the methods are complementary.

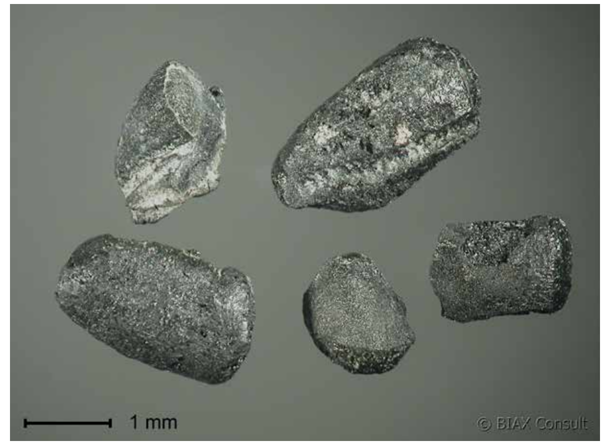


Fig. 11.6 Fragmented cereal grains from Tiel Medel, sample V8159/S1682 under low magnification binocular, showing the characteristic bulging on the fracture surface which suggests the fragmentation of grains prior to charring (photo: M. van Waijjen).

In Medel, porridge-like meals were cooked in small pots, some of which were Kugelbechers.

Particles of single-layered aleurone tissue embedded in residue matrices suggest that grains of emmer/einkorn or (durum) wheat (*Triticum* sp.) were prepared (Fig. 11.8). It seems that no other components were added to these cereal-based dishes at Medel, as no chemical markers other than a mixture of charred polysaccharides and proteins which were probably derived from grain were found (Kubiak-Martens and Oudemans, in prep). But not only cereals were cooked in vessels at Medel. In some, mainly large pots, numerous fish scales and fish bones were detected in organic residues. This would suggest that the entire fish, or chunks of fish, with the scales and bones would have been cooked in the Swifterbant pots.

Food crust assemblages from other Swifterbant sites also revealed SEM evidence for cooking porridge-like meals. At the Swifterbant-S3 site, for example, the remains of light emmer chaff (lemma/palea or glume) were found in many pots with organic residues, suggesting that porridge-like food would have been prepared in those pots. It appears that at S3, the emmer grain meals were mainly cooked in medium-sized pots. This SEM-defined group of emmer-based meals was supported by the chemical (DTMS) analysis which (in many cases) revealed the presence of

Fig. 11.7 Charred organic residue encrusted on the exterior surface of one of the sherds from Tiel Medel (TR06/V16978) (photo: Tania F.M. Oudemans, KenazConsult & Laboratory, Berlin).

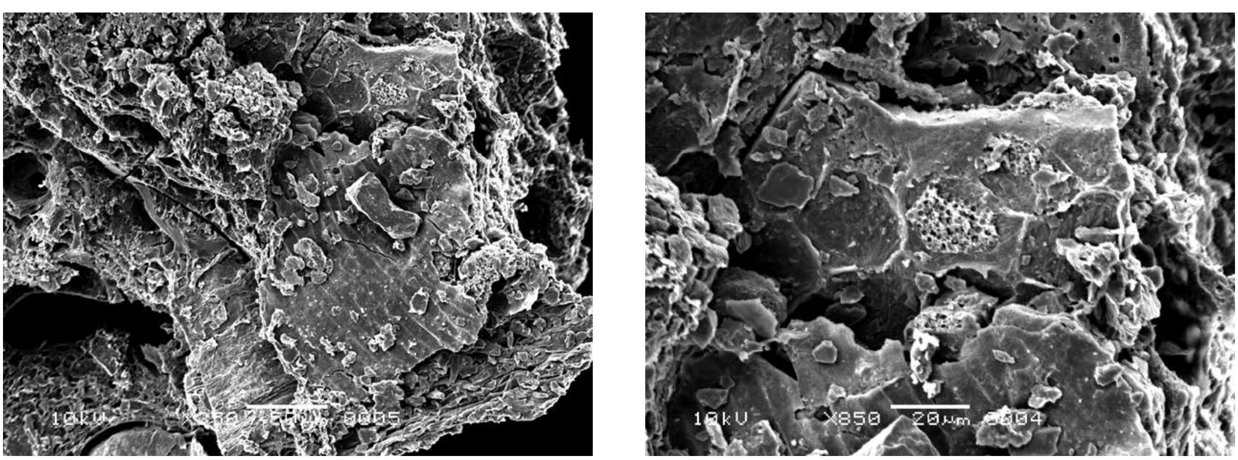


Fig. 11.8 SEM micrographs showing the internal microstructure of one of the food crusts from Medel (TR04/V17243), showing aleurone tissue embedded in the residue matrix (a) detail (b) single-layered aleurone likely from emmer/einkorn or (durum) wheat (photos: L. Kubiak-Martens).

carbohydrates in the chemical spectra. In one of the pots, emmer was cooked together with fish as indicated by the presence of fish scales embedded in the residue matrix (Raemaekers et al 2013). The combined molecular and isotopic analyses of lipids that were recently performed on a series of organic residues from S3 yielded clear evidence for the processing of freshwater fish in all of the studied pots (Demirci et al 2020). Also at S4, emmer was often cooked with other components, fish in particular as indicated by the presence of fish scales embedded in residue matrices (in some pots) and by the molecular biomarkers indicative for the processing of freshwater fish. It seems that at both sites S3 and S4 grain was often (perhaps always) cooked with other components, often with fish and sometimes with the addition of green vegetables (Raemaekers et al 2013). It is hard to define whether these mixed dishes were cereal-based porridge-like meals cooked together with the fish, or rather fish-based stew-like meals cooked with the addition of cereals. One thing is clear, fish and emmer grain was cooked together.

11.4 Concluding thoughts

The cereal-based products preserved at the Swifterbant sites, Medel in particular, have significant implications for the way we view the cereal element in the Early Neolithic subsistence diet. At Medel, the cereal spectrum consisted of four different species, two hulled (emmer and einkorn) and two free threshing cereals (naked barley and tetraploid free threshing wheat, likely durum wheat). Free threshing tetraploid wheat was identified for the first time from the Swifterbant culture site.

At Medel, the cereals were processed locally and probably grown locally. Small plots of emmer (probably accompanied by einkorn) and plots of barley and durum wheat would have been located on small, elevated levees, presumably near the houses. The presence of archaeological remains, such as sickles with gloss and quern stones, may also indicate that cereals were harvested locally and were processed at the site.

The spectrum of cereals, and also that of the small amount of potential arable weeds, connects the Swifterbant cereal assemblage with that of contemporaneous cultures from the German Rhineland, Bischheim, and early Michelsberg. The tetraploid free threshing wheat was probably adopted through southern or southwestern pathways, and most likely from the Bischheim tradition. The Medel farmers, however, cultivated a reduced crop spectrum, compared with Bischheim farmers: namely, no oil or fibre plants or pulses. Swifterbant agriculture was likely focused on cereal cultivation. One may wonder whether wild plants such as nettle or bramble were used for fibre extraction and if animal fat and hazelnut oil would have been preferred over plant oil from crop plants.

The frequent finds of cereals throughout the site suggest that they must have been a regular and possibly substantial component of the Swifterbant diet at Medel, where the grain was transformed into food. Among the cereal-based foods are flatbread-like products made of einkorn/emmer/durum wheat or barley. Grain was also ground or crushed into a grist prior to cooking, likely intended to be cooked in ceramic vessels either as porridge-like food or some kind of bulgur.

The image that seems to arise as a result of organic residue study is that in the Swifterbant culture the cooking of grain as porridge-like meals was performed in specially selected pottery, although the choices for specific pottery may have differed per Swifterbant site or possibly per region. Various methods of cereal-based food preparation would also suggest that the cereals were consumed on a regular, and possibly daily, basis.

The presence of cereal-based meals is especially important for our understanding of the Swifterbant culinary practice and the diversity of food choices but also for a more accurate evaluation of the neolithisation process on the Dutch wetland sites.

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Chapter 12

Cooked and raw. Fruits and seeds in the Iberian Palaeolithic

Ernestina Badal, Carmen M. Martínez Varea

> [Man] *has discovered the art of making fire, by which hard and stringy roots can be rendered digestible, and poisonous roots or herbs innocuous.*
> Darwin 1871: 278

Abstract

Fruits, seeds, leaves and underground storage organs were all consumed by human groups during the Palaeolithic. These plant foodstuffs provided humans with minerals, vitamins and nutrients essential for optimal health. In this sense, fire control was a crucial human achievement since cooking allowed the physical and chemical modification of these elements by eliminating toxins, enhancing the digestion of foodstuffs and increasing their energy value. The use of fire during plant processing increases the potential preservation of archaeobotanical remains, as well. Based on the preserved plant elements and their characteristics, the *chaîne opératoire* of plant consumption can be reconstructed.

In this chapter we focus on the gathering and processing of fruits and seeds of three plant species during the Palaeolithic in the Iberian Peninsula. We stress the role of fire as a processing tool and as a preservation agent. The plants in question are *Pinus pinea* L. (stone pine), *Corispermum gallicum* Iljin (bugseed), and *Corema album* (L.) D. Don ex Steudel (Portuguese crowberry). The archaeobotanical remains preserved in the three sites discussed here, namely Figueira Brava (Setúbal, Portugal), Cueva de Nerja (Málaga, Spain) and Cova de les Cendres (Alicante, Spain) prove that Neanderthals and modern humans had similar skills regarding the control of fire during all stages of the combustion process, and demonstrate the implementation of multi-step processing, especially at the end of the Upper Palaeolithic. By avoiding cutting down the species that provided food, these Palaeolithic groups carried out sustainable vegetation management, as well.

Keywords: *Palaeolithic, food processing, pine nuts, berries, seeds, fire*

12.1 Introduction

Throughout history, humans have had an omnivorous diet, although some foodstuffs are frequently “missing” from the archaeological record, such as plant foods. The documentation of the consumption of plants during the Palaeolithic is not easy due to the scarce generated waste and their perishable nature. Nevertheless, recent developments concerning the analysis of macro- and micro- archaeobotanical remains from Palaeolithic

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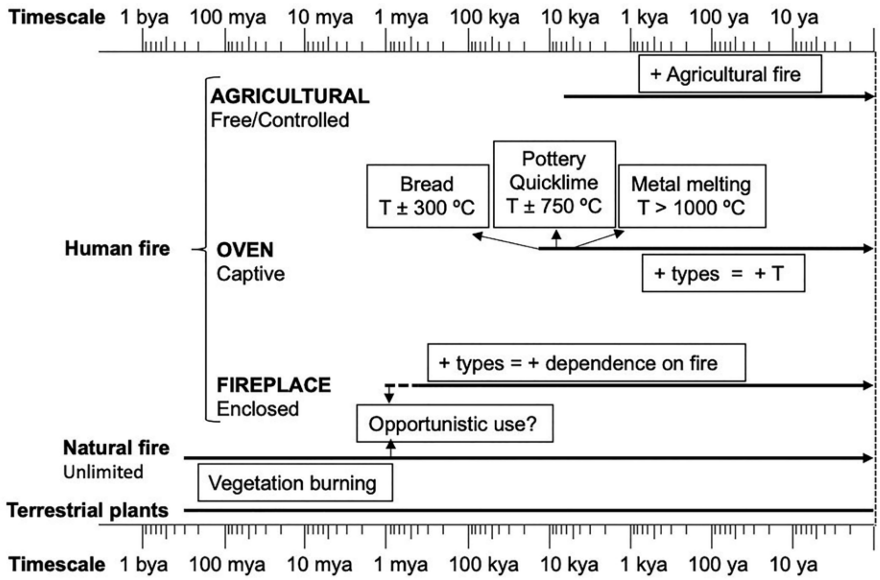

Fig. 12.1 Time scale of natural and human fire. As time goes by, types of combustion structures diversify and the reached temperatures increase.

sites are providing valuable evidence on plant food gathering and processing among hunter-gatherer groups (Asouti et al 2018; Henry et al 2014; Mariotti Lippi et al 2015; Martínez-Varea 2020; Miras et al 2020; Riehl et al 2015), filling gaps in the hitherto limited knowledge about plant use during this period.

Fruits, seeds, leaves, stems and underground storage organs of wild plants can be ingested raw or somehow processed to eliminate toxins or to ease digestion. In this sense, the domestication of fire was an inflection point in the use of plants (Stahl 1984).

In this chapter we focus on the gathering and processing of pine nuts (*Pinus pinea*), bugseeds (*Corispermum* cf. *gallicum*) and Portuguese crowberries (*Corema album*) during the Middle and Upper Palaeolithic in the Iberian Peninsula, as remains of these plants have been recovered in some archaeological sites. The significant amount of archaeobotanical remains suggests that these plants played an important role in human diet. We also examine the potential role of fire as a processing tool and as a preservation agent.

12.2 Fire as a key ally for humankind

Fire is a powerful natural force, unlimited and of great destructive power and, as such, it has had a crucial influence in the evolution of living beings, and of humankind in particular. The production, control and use of fire are exclusively human achievements, which break the equality relations with the other living organisms (Goudsblom 1992). In order to control fire, it is essential to understand its behaviour, namely how it is produced, how it spreads and what its consequences are; in this respect fire control is a result of learning and transmission which requires the development of some abilities among hominids, and specifically of their "powers of observation, memory, curiosity, imagination, and reason", as pointed out by Darwin (1871, 278). The ability to manage fire is a universal human milestone, but the date of this achievement is still debated (Alperson-Afil 2008; Roebroeks and Villa 2011). Throughout the history of humankind, climatic changes, the history of fire and cultural changes are somehow related. In each evolutionary phase, humans have diversified the uses of fire -heat, light, transformative tool, etc-, have generated more energy via the development of new combustion structures (e.g. domestic and industrial ovens), new fuels (e.g. coal, petroleum or gas), and have increased its destructive power (Fig. 12.1).

The domestication of fire implies the capacity to limit it within a combustion area. In dwellings, human fire is always bounded, and its action is reduced and centered in the combustion structure, namely the hearth, where the input of fuel is limited and controlled. In agriculture, human fire is generally limited to crop fields, although it can become uncontrolled and cause larger fires (Fig. 12.1). Even so, the products of human fire are the same as those of natural fires: wood charcoal, ashes and others (Perlès 1977).

Some researchers link the first consumption of plant food to the development of fire control since it allowed the elimination of toxins present in some plants (Leopold and Ardrey 1972). However, even before the control of fire, hominids could still minimize the intake of toxins through a diversified spectrum of ingested plants, along with other processing techniques developed in the course of the emergence of the genus *Homo* (Hillman and Wollstonecroft 2014; Stahl 1984). Cooking, that is processing of food ingredients by fire, alters the texture and taste of foodstuffs, rendering them more digestible and increasing their energetic content, thus enabling increase in brain and body size (Carmody and Wrangham 2009; Wollstonecroft

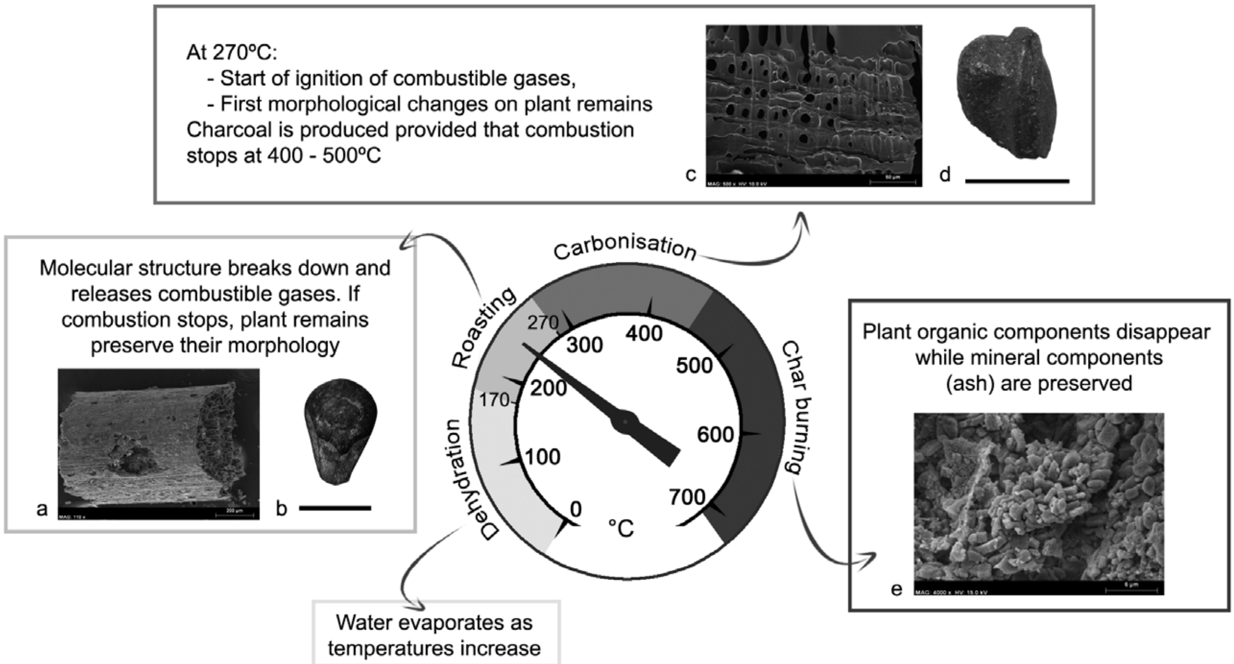

Fig. 12.2 Fire combustion process and generated plant residues: a *Pinus* sp. needle from Figueira Brava; b pine scale from Cueva de Nerja; c *Pinus pinea* wood charcoal from Cueva de Nerja; d altered *Corispermum* cf. *gallicum* seed from Cova de les Cendres; e ashes from Cova de les Cendres.

et al 2012). Physiological consequences of adaptation to the ingestion of cooked foodstuffs are first observed among *Homo erectus* some 1,8 m years ago (Wrangham and Carmody 2010). Therefore, "through food processing, hominins had an active role in their own evolution" (Butterworth et al 2016, 45). In this respect, Parker et al's (2016) pyrophilic primate hypothesis is quite intriguing: first hominids were aware of the benefits of recurrent natural fires in the savannah, as they generated open spaces where gathering was easier, thanks to the increased visibility and to the presence of "cooked" foodstuffs. Hominids, then, started to spread these natural fires, understanding quite early the benefits of cooking, leading to evolutionary adaptation. In any case, if we accept that *Homo erectus* were the first hominids to exhibit clear physiological adaptation to a cooked diet, we can hypothesize that they could occasionally have used fire with different aims, originally as active pyrophilics and then by acquiring the necessary experience and knowledge in order to control and produce it (Attwell et al 2015). We do not know the exact details of this learning process, but the benefits of fire as an evolutionary success are undeniable (Darwin 1871; Wrangham 2009).

In the Iberian Peninsula, evidence of possible use of fire appears in as early as the Lower Palaeolithic (MIS 11, ca 400 ky), while the ability of Neanderthals to produce and control it in all the combustion phases, same as modern humans, is beyond doubt (Sanz et al 2020; Vidal-Matutano et al 2019; Zilhão et al 2020).

12.3 Fire as a key ally to Archaeobotany

Fire is also considered an ally to Archaeobotany because carbonisation is the main preservation agent of plant remains in archaeological deposits; fire could also be considered as a destructive agent (Wilson 1984) since it causes preservation biases depending on the characteristics of the plant remains and the combustion conditions (Wright 2003).

The combustion process consists of four different phases: dehydration, roasting, carbonisation or pyrolysis and char burning (Chabal et al 1999). The generated remains differ according to which stage the firing stops, and they can demonstrate the use of fire during plant processing (Fig. 12.2). Carbonisation, according to Wright, is "the process by which incomplete combustion of tissues leaves a carbon residue that is black in colour" (2003, 578), the physical and chemical properties of which vary depending on heating variables (Braadbaart and Poole 2008).

12.4 From gathering to consumption

The *chaîne opératoire* of plant use during the Palaeolithic consists of six steps: gathering, transport, storage, processing, consumption and discard. The presence or absence of archaeobotanical remains in the archaeological deposits and their frequency allow us to more or less accurately detect these human actions (Berihuete 2016) (Fig. 12.3), although other factors (e.g. taphonomic

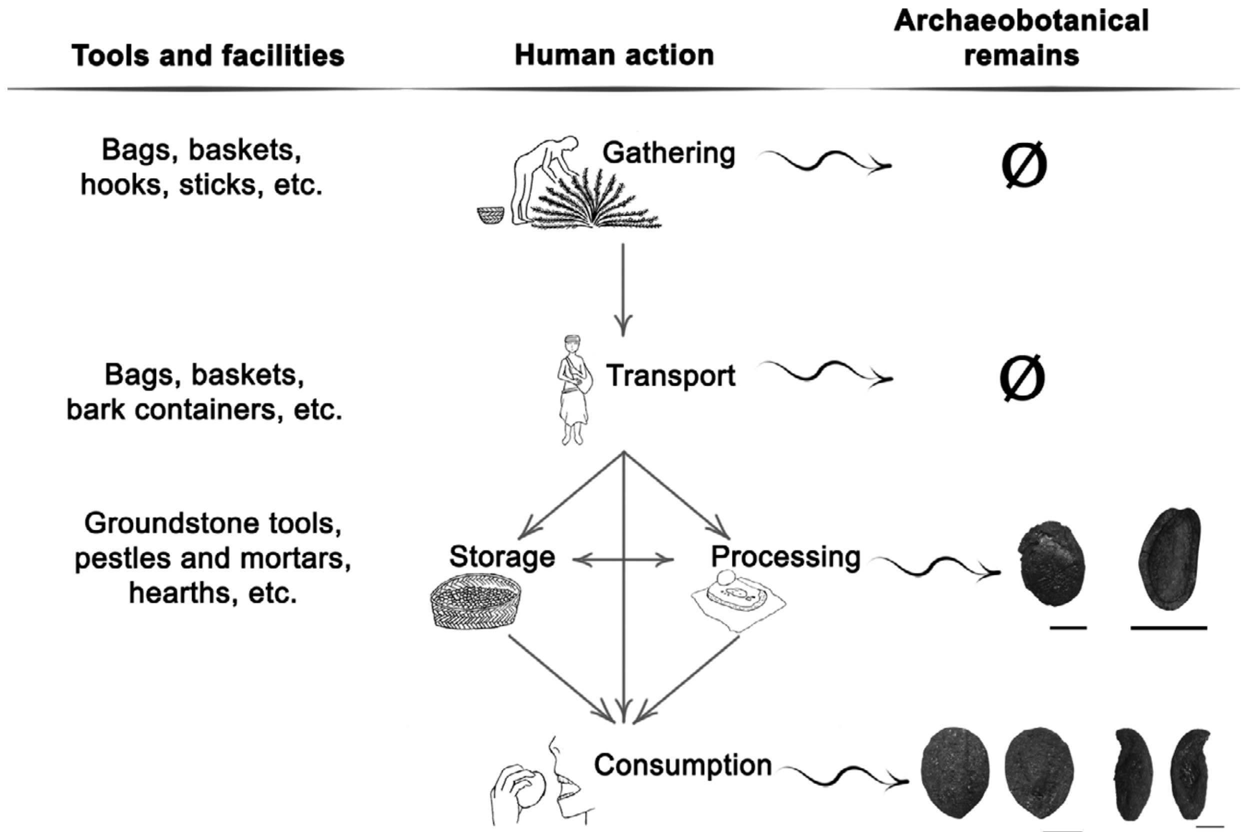

Fig. 12.3 *Chaîne opératoire* of plant food processing during the Palaeolithic.

alterations) must be considered when assessing the composition of archaeobotanical assemblages (Wright 2003).

Given the ease and the reduced risk involved in plant gathering, usually all members of Palaeolithic groups could participate in the gathering of some plant food resources, such as Portuguese crowberries, wild strawberries, etc regardless of gender or age (Fig. 12.4). However, gathering other fruits requires some skills and entails some risks, so it was probably carried out by trained members of the group; this is the case of the cones of the stone pine. In any case, gathering fruits and seeds is less dangerous than hunting, although both activities require specific skills and knowledge since the consumption of a toxic fruit could cause death.

Gathering itself does not leave any archaeological evidence. In fact, some of the collected foods could be consumed outside the habitat, in the very place of gathering, especially in the case of fruits that could be eaten raw. Regarding gathering tools, use-wear analyses that could shed some light on this subject are, unfortunately, not frequent (Pyżewicz and Nerudová 2020), while implements involved in it -baskets, bags, digging sticks or hooks- were made on perishable materials, and are, thus, rarely preserved (Aranguren et al 2018; Aura et al 2020). Concerning catchment area size, it varied according to the biodiversity of the territory, usually covering an area ranging from the immediate surroundings of the sites to as far as a 10 km radius (Martínez-Varea 2020) around them.

A post-harvesting process is carried out in order to remove the non-edible parts, to eliminate toxins and other components, to ensure preservation, to improve taste and texture, and to facilitate access to some nutrients (Stahl 1989). This process varies according to the characteristics of each fruit or seed: some fruits, like wild strawberries, could be consumed immediately because they can be eaten raw or because they cannot be stored; other fruits, like cones, acorns or hazelnuts, can be stored for months. In this case, some processing is needed to access the edible seeds or to ensure their preservation -for instance through roasting- as has been documented for hazelnuts in some Mesolithic sites (Bishop et al 2014). Other plant foods, like legumes (Valamoti et al 2011) or Chenopodiaceae (López et al 2011), require some processing before their consumption. The use of fire during this process or the removal of the discarded parts increases the possibilities of preservation of archaeobotanical remains and allows the reconstruction of the *chaîne opératoire* and of plant

Fig. 12.4 Reconstruction of gathering of *Corema album* berries in the surroundings of Cova de les Cendres. Illustration by Sara Pastrana Herrero.

diet during the Palaeolithic. In fact, as Dennell pointed out, "it is certainly a disturbing possibility that much of our archaeobotanical evidence might provide a more accurate indication of what was thrown away than of what was actually eaten" (1976, 232).

12.5 Fruits and seeds in the Iberian Peninsula during the Palaeolithic

Among the spectrum of plant foods available during the Palaeolithic in the Iberian Peninsula, gathering and consumption of pine nuts (*Pinus pinea*), bugseeds (*Corispermum* cf. *gallicum*) and Portuguese crowberries (*Corema album*) have been detected in Figueira Brava, Gorham's and Vanguard Cave, Cueva de Nerja, and Cova de les Cendres, thanks to the use of fire at some point during their processing.

12.5.1 Stone pine (Pinus pinea L.)

Pinus pinea nowadays grows on coastal and continental areas, especially on sandy soils, where it forms dense masses (Fig. 12.5). In the Iberian Peninsula, stone pines grow at altitudes ranging from sea level to 1000 masl, with a mean annual temperature tolerance from 13ºC to 19ºC. They can thrive in areas with a mean annual precipitation of 250-1000 mm, withstanding summer droughts (Montoya 1990).

Flowering occurs in spring and maturation of cones takes three years. In the third year ripening occurs, and cones reach their final size (8-14 cm). Therefore, during the third autumn, cones are mature and closed, and during the next spring, as heat dilates their resin, they open, and the stones are dispersed by gravity.

Pine nuts have a thick woody shell (Fig. 12.7) that protects the edible seed, which can be eaten raw, roasted or boiled. Their nutritional value is outstanding, because of their high content in monounsaturated fat, omega-3 fatty acids and vitamin E (Moreiras et al 2016). Unsaturated fat reaches 89% of the lipids, with a predominance of polyunsaturated fatty acids (60%) over the monounsaturated (29%). Pine nuts are also

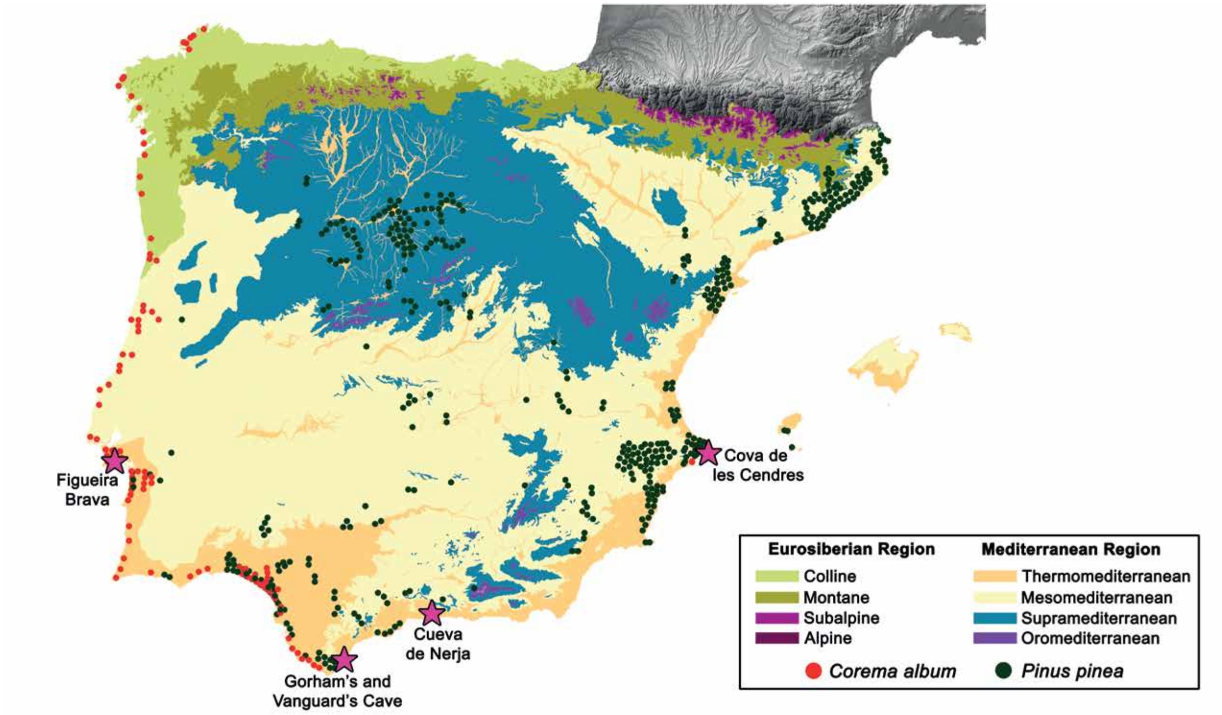

Fig. 12.5 Current distribution of *Pinus pinea* and *Corema album* populations in the Iberian Peninsula (based on www.anthos.es) (*Corispermum gallicum* is no longer present) and location of the main archaeological sites mentioned in the text. Map of bioclimatic belts based on Rivas-Martínez 1987.

high in phosphorus, magnesium, calcium, zinc, iron and other minerals essential for a healthy circulatory and nervous system (Nergiz and Dönmez 2004). In the Iberian Peninsula leaves, wood, bark and fruits of stone pine have traditionally been used (Rivera and Obón 1991).

Some researchers place the origins of *Pinus pinea* in the Eastern Mediterranean and date its introduction to the western part of the basin in historical times (Ceballos and Ruiz de la Torre 1979). Archaeobotanical data, however, prove that the stone pine was present in the Iberian Peninsula at least since the Middle Palaeolithic (Badal 1990; Metcalf 1964). Excavations in Figueira Brava (Setúbal, Portugal), Gorham's and Vanguard Cave (Gibraltar) and Cueva de Nerja (Málaga, Spain) have provided abundant remains of stone pine (Fig. 12.5).

Gruta da Figueira Brava is on the coast of the Serra da Arrábida (Setúbal), on the mouth of the estuary of the Sado River (Fig. 12.5). The cave opens onto a beachrock-covered regularised platform that lies at ~5 masl and corresponds to the Last Interglacial marine terrace. Four Middle Palaeolithic phases with remains of Neanderthal occupations have been identified in this sequence. The first three phases (FB1, FB2 and FB3) are dated to MIS 5c, while phase FB4 to MIS 5b (Zilhão et al 2020). Here we present the archaeobotanical data from phases FB2, FB3 and FB4.

Gorham's Cave and Vanguard Cave (Gibraltar), located close to the current marine shore (Fig. 12.5), provide, through their thick Middle Palaeolithic sequence, evidence of Neanderthal occupations, along with archaeobotanical remains. *Pinus pinea* remains, although documented, are scarce in Vanguard Cave. The archaeobotanical sequence of Gorham's Cave, on the other hand, is more complete. Here we focus on the results from the Middle Palaeolithic layer SSLm(Usm).2, whose chronology should be similar to that of Figueira Brava, as recently argued (Zilhao et al 2020, 74 S.I.), and on those from the Early Gravettian layer CHm5 published by Ward et al (2012a and b).

Cueva de Nerja is located on the south side of the Almijara Mountain (Nerja, Spain), at an altitude of 158 masl and approximately 1 km away from the nearest coastline (Fig. 12.5). The archaeological deposits in the Vestíbulo area cover the Upper Palaeolithic and partially the Mesolithic and Neolithic (ca 24000-4000 BP) (Aura et al 2002; Badal 1998).

All four sites are placed near the current coastline, in the warmest bioclimatic region of Europe, that is the thermomediterranean bioclimatic belt, with a mean annual temperature of 17ºC-19ºC (Fig. 12.5). Here thrive typical Mediterranean sclerophyll forests with *Quercus*, *Olea*, *Pistacia*, etc and thermophilous pine forests, where *Pinus pinea* is always present.

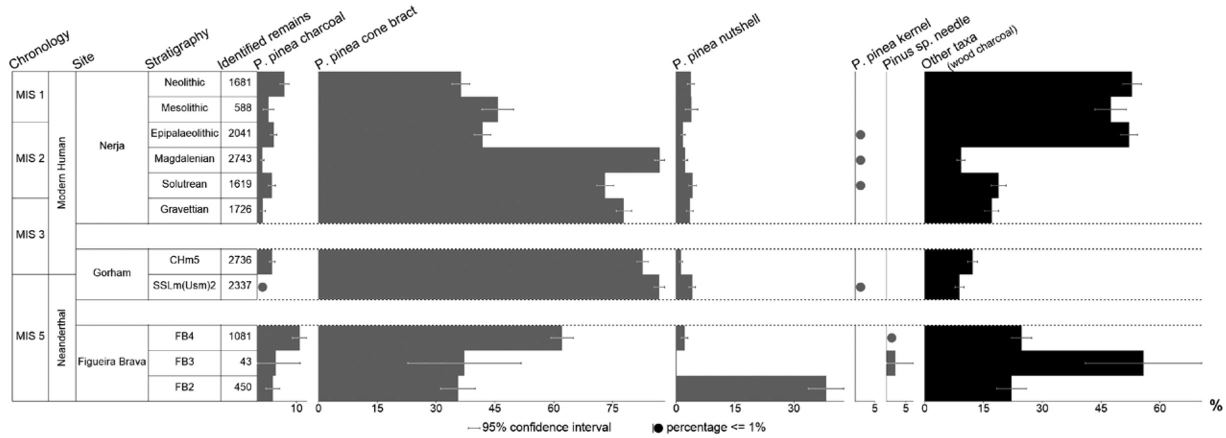

Fig. 12.6 Frequency of *Pinus pinea* remains and other taxa wood charcoal in Figueira Brava, Gorham's Cave and Cueva de Nerja. Data from Zilhão et al 2020, Ward et al 2012b and Badal 1990.

Table 12.1 *Pinus pinea* remains and other taxa wood charcoal from Figueira Brava (Setúbal, Portugal), Gorham's Cave (Gibraltar) and Cueva de Nerja (Málaga, Spain). Data from Zilhão et al 2020, Ward et al 2012b and Badal 1990.

Chronology		**Site**	**Stratigraphy**	**Identified remains**	***P. pinea* wood charcoal**	***P. pinea* cone bract**	***P. pinea* nutshell**	***Pinus* sp. needle**	***P. pinea* kernel**	**Other taxa (wood charcoal)**
MIS 1	Modern Human	Nerja	Neolithic	**1681**	117	611	64	0	0	889
			Mesolithic	**588**	17	269	23	0	0	279
MIS 2			Epipalaeolithic	**2041**	85	854	36	0	2	1064
			Magdalenian	**2743**	35	2386	65	0	2	255
			Solutrean	**1619**	60	1184	68	0	1	306
MIS 3			Gravettian	**1726**	26	1345	60	0	0	295
		Gorham	CHm.5	**2736**	105	2262	34	0	0	335
MIS 5	Neanderthal		SSLm(Usm).2	**2337**	1	2031	96	0	1	208
		Figueira Brava	FB4	**1081**	117	672	23	2	0	267
			FB3	**43**	2	16	0	1	0	24
			FB2	**450**	18	160	172	0	0	100

Table 12.2 Radiocarbon dating on *Pinus pinea* remains from Cueva de Nerja (Málaga, Spain).

Material	**Years BP**	**Yrs cal BP**	**Laboratory**	**Reference**
Pinus pinea L. cone bract	24730±250	30400 – 29160	Gif A-102023	Jordá and Aura 2008
Pinus pinea L. cone bract	24200±200	29730 – 28410	Beta-189080	Jordá and Aura 2008
Pinus pinea L. cone bract	21140±190	26000 – 24720	Gif A-102021	Jordá and Aura 2008
Pinus pinea L. charcoal	18490±70	22280 – 22030	Beta-362535	Unpublished
Pinus pinea L. nutshell	12360±60	15370 – 14590	Beta-189081	Jordá and Aura 2008

Pinus pinea remains are extremely abundant throughout the sequences of these sites (except for Vanguard Cave) (Fig. 12.6, Table 12.1), especially in Cueva de Nerja, where 7,330 out of 10,398 identified archaeobotanical remains from the entire sequence were classified as *Pinus pinea* (including wood charcoal, cone bracts, nutshells and kernels) (Table 12.1). Some radiocarbon dates were obtained on macroremains of this taxon (Table 12.2), as well.

The proportion of the reproductive remains of stone pine is noteworthy in all four sites (Fig. 12.6, Table 12.1), especially concerning the cone scales whose presence varies from 35.6% of the analysed charred remains in the Middle Palaeolithic of Figueira Brava 2 to 87% during the Magdalenian of Cueva de Nerja (Fig. 12.6). Nutshells were documented in all analysed levels, but their percentages are lower to those of the cone scales, ranging normally

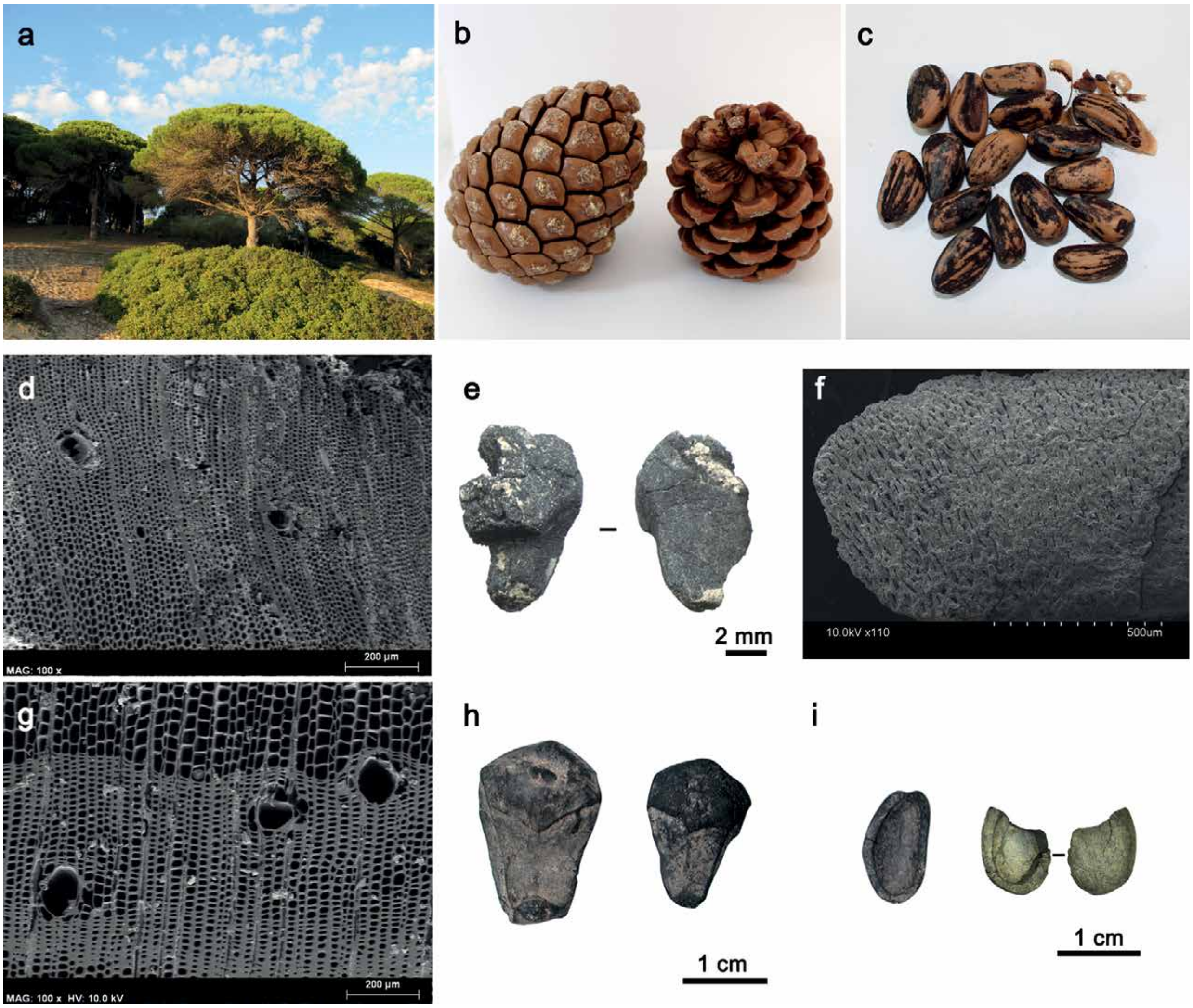

Fig. 12.7 a Current *Pinus pinea* forests; b cones; c pine nuts; d, e, f *Pinus pinea* remains from Figueira Brava; g, h, i *Pinus pinea* remains from Cueva de Nerja (d, g charred wood – transverse section; e, h cone bract; f, i nutshells).

between 1% and 5%, except for Figueira Brava 2 (FB2), where they represent 38.2% of the assemblage. On the contrary, seeds are almost absent: one specimen was documented in layer SSLm(Usm).2 from Gorham's Cave and five in Cueva de Nerja (Table 12.1).

In the case of the stone pine vegetative remains, some needles were documented in Figueira Brava, while wood charcoal was preserved in all sites. However, the proportions of the latter stand out when compared to other woody taxa charcoal: *Pinus pinea* wood charcoal is always lower than 10% of the charred wood, while that of other taxa (conifers and angiosperms) is dominant in all cultural phases – even in the Neolithic of Cueva de Nerja (Fig. 12.6). This suggests that human groups selected for firewood species that did not provide them with fruits since the proportion of the reproductive remains of stone pine at the four sites indicates management focused on nut consumption. These data suggest sustainable management of stone pine resources during both the Middle and the Upper Palaeolithic.

Wood charcoal fragments from Figueira Brava and Cueva de Nerja do not preserve their external morphology because combustion stopped during the carbonisation phase (T > 280-300ºC), but they do preserve the wood anatomy. Stone pine needles, cone scales and nutshells, on the contrary, preserve their morphology, because roasting stopped before ignition (T < 280ºC) (Fig. 12.7). Had they been gathered as fuel, their proportion would have been similar to other taxa (i.e. other conifer and angiosperm) present in the Mousterian, Upper Palaeolithic and Neolithic levels (Fig. 12.6) and they would have rarely preserved their external morphology; due to their high content in resin, a volatile and flammable substance, the cones are extremely susceptible to turn to ashes when combustion starts. Their

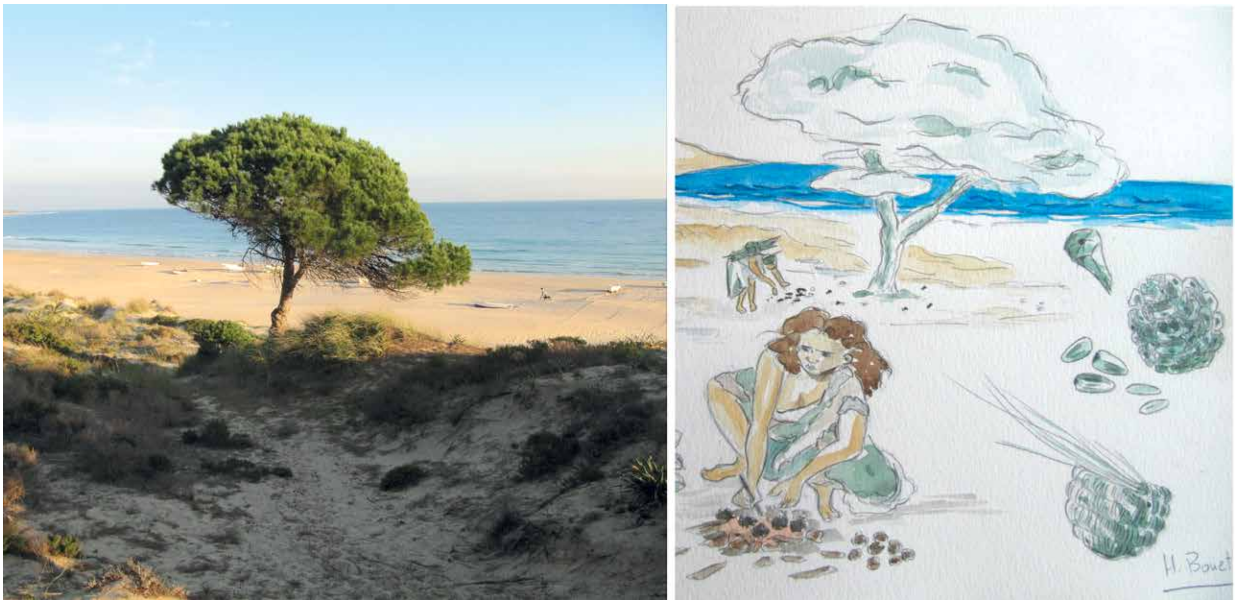

Fig. 12.8 *Pinus pinea* in Bolonia's dunes (Cádiz, Spain) and reconstruction of the gathering and processing of stone pine cones during the Palaeolithic. Illustration by Helena Bonet.

presence could, therefore, be probably related to food gathering and not to fuel collection. The presence of *Pinus pinea* wood charcoal is probably the result of the burning of the small fragments of branches still attached to the gathered cones.

The composition of the archaeobotanical assemblage of Figueira Brava, Vanguard and Gorham's Cave and Cueva de Nerja, is the result of selective human action, as in the case of marine and terrestrial animal resources (Aura et al 2002; Barton et al 2012, Colonese et al 2011; Zilhão et al 2020).

Bearing in mind the edaphological requirements of *Pinus pinea*, the abundance of its remains sustains the hypothesis of the existence of pine forests in the dune system in front of the studied caves, when sea level was lower than currently, during MIS 5 and MIS 3-2 (Barton et al 2012; Jordá et al 2011; Zilhão et al 2020). Both Neanderthals and modern humans visited these coastal areas in order to obtain firewood and food.

The high presence of cone bracts in the archaeological sites suggests that Neanderthals and modern humans probably gathered the cones when they were mature but closed, that is during the autumn or winter of the third year after fecundation, as currently performed in Iberia (Montoya 1990) (Fig. 12.8), thus avoiding the loss of nuts. They transported the cones to the caves, where they could expose them to the nearly extinguished embers or place them around the hearths. As heat dilated the resin, the cones would open, and about 100 pine nuts for each cone (Montoya 1990) could be released by simply hitting the cones. This process could have been performed in all the analysed archaeological sites, from the Middle Palaeolithic to the Neolithic, and it has also been documented for *Pinus halepensis* in the Capsian site of El Mekta (Tunisia) (Morales et al 2015). Pine nuts were then probably broken with a hammerstone to obtain the seeds. Nutshell fragments from Figueira Brava are too small to carry out an analysis of their processing. However, some of the remains recovered in Cueva de Nerja bear notches caused by hammering, although we cannot dismiss that they could have been opened by warming as in the case of the cones. Once obtained, pine stone seeds are completely edible, and in fact their intake could explain their scarcity in the assemblages (6 seeds among the 17045 analysed remains).

Obtaining pine nuts requires experience and great control of fire to avoid the complete carbonisation of the cones, skills that characterized both Neanderthals (Figueira Brava and layer SSLm(Usm).2 from Gorham's Cave) and modern humans (Cueva de Nerja and layer CHm5 of Gorham's Cave) alike.

12.5.2 Bugseed (*Corispermum gallicum Iljin*)

Bugseed or *Corisperme à fruits ailés* is an annual herbaceous plant that nowadays grows on sandy coastal soils in the south of France, in the Camargue region. Although this species is no longer present in the Iberian Peninsula, it grew on the coast near Tarragona during the second half of the 19th c (Wilkomm 1893, 63).

Corispermum is taxonomically one of the most problematic genera of the Chenopodiaceae (Sukhorukov 2007), and its origin is a conundrum: its native range is South Siberia, although the subspecies *C. pallasii* subsp.

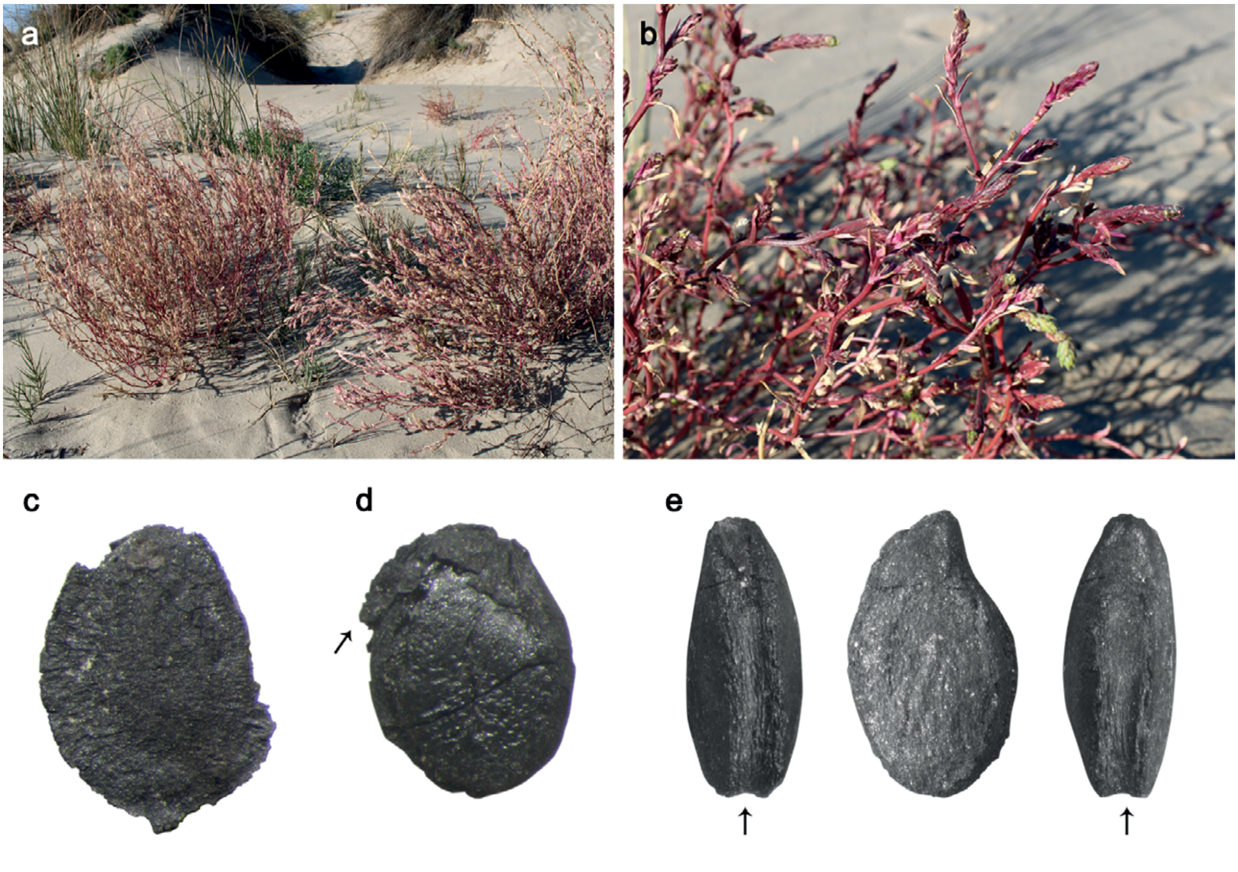

Fig. 12.9 *Corispermum gallicum*. a plant; b infructescence detail; c, d, e archaeobotanical remains from Cova de les Cendres: morphological changes derived from their processing (marked with an arrow and explained in the text). Scale bar 1 mm.

membranaceum is considered native to Eastern and Central Europe (POWO), and *C. gallicum* is considered native to France (Tison et al 2014, 1203).

The plant rises to 60 cm height and ramifies from the base. Its inflorescences are usually compact and dense (Fig. 12.9a-b). The bugseed produces obovate or obovate-oblong, strongly compressed, winged achenes (Aellen 1964). It blooms from June to September (www.pladias.cz) and seeds are ripe from July to September.

Some genera in the Chenopodiaceae family provide two types of food: greens and seeds. Leaves of *Atriplex hortensis* and *Chenopodium album*, for instance, can be ingested cooked or raw. The seeds of *Chenopodium album* were transformed into flour in Europe during periods of shortage (Font Quer 1999, 152-157), and those of *Atriplex halimus* are ingested boiled by the Tuareg (Rivera and Obón 1991, 361-362). No information on the uses of *Corispermum gallicum* has been found, but another species of this genus, *Corispermum dilutum*, whose characteristics are similar to those of *C. gallicum*, produces seeds that are gathered by the Mongol tribe Arhorchin. They consume them as a grain substitute cooked by dry roasting (Huai and Pei 2000). Like other Chenopodiaceae, *Corispermum* spp. grains are a source of proteins and fatty acids.

Some taxa included in the Chenopodiaceae family are present in Palaeolithic and Mesolithic sites, such as Kebara (Lev et al 2005), Halsskov (Kubiak-Martens 2002), Tybrind Vig (Kubiak-Martens 1999) or Ohalo II, where the abundant seeds and fruits of *Atriplex rosea/leucoclada* found near a grinding stone were considered as food remains (Weiss et al 2008). The contribution of *Chenopodium album* to the diet of the first farming communities in central Poland has been suggested by Mueller-Bieniek et al (2019), and the consumption of this species has been directly documented for the Iron Age with the intestinal contents of the bog bodies (Behre 2008).

Corispermum cf. *gallicum* has been identified among the plentiful archaeobotanical assemblage of Cova de les Cendres, a site located on the cliffs of the Moraira headland (Teulada-Moraira, Spain), at an altitude of 60 masl right on the modern coast. Inside this wide cave, a long Upper Palaeolithic archaeological sequence has been documented (Villaverde et al 2019); its archaeobotanical assemblage has provided exceptional data for the

	Level XVIA (Gv)	Level XV (Gv)	Level XIII (Sl)	Level XII (MM)	Level XI (UM)	Total
Corispermum cf. *gallicum*	75	33	6	262	9	**385**
Reproductive remains	27192	5110	370	1043	1729	**35444**

Table 12.3 *Corispermum* cf. *gallicum* remains recovered in the Gravettian (Gv), Solutrean (Sl), Middle Magdalenian (MM) and Upper Magdalenian (UM) of Cova de les Cendres.

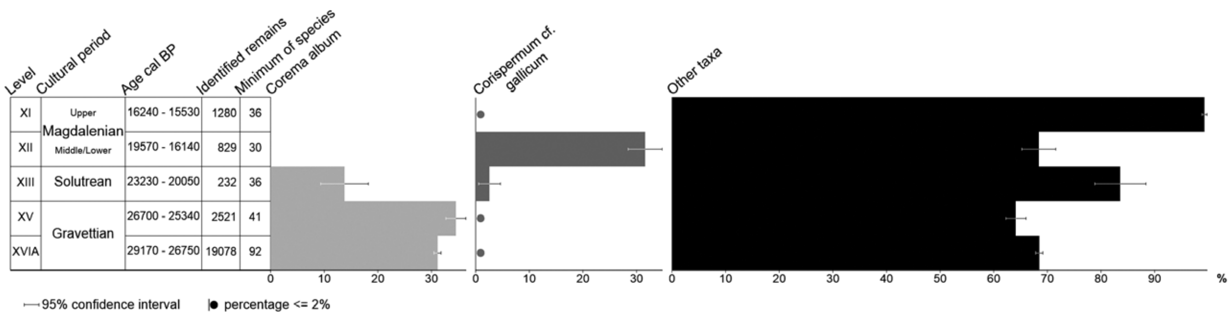

Fig. 12.10 Frequency of *Corispermum* cf. *gallicum*, *Corema album* and other taxa seeds and fruits in Cova de les Cendres.

reconstruction of the use of plants by Palaeolithic hunter-gatherers (Martínez-Varea 2020).

Different taxa of the Chenopodiaceae family -among others- have been documented throughout the Upper Palaeolithic sequence of the cave, but the presence of *Corispermum* cf. *gallicum* stands out. Seeds of bugseed are present at all the analysed levels, from the Gravettian to the Upper Magdalenian, although their presence is especially remarkable during the Middle Magdalenian when it represents more than 25% of the 1043 plant reproductive remains (Table 12.3, Fig. 12.10). As far as we know, this is the only archaeological record of this taxon in the Iberian Peninsula.

The grains of *Corispermum* cf. *gallicum* as well as those of other Chenopodiaceae, Fabaceae and Poaceae documented in Cendres, could be eaten as whole seed or ground. As previously pointed out, we found no ethnographic information about the processing of *Corispermum gallicum* grains, but we can take into account first the processing of *Corispermum dilutum* by the Arhorchin (Huai and Pei 2000) who dry roast the grains, and second the traditional processing of *Chenopodium quinoa* var. *quinoa* Willd. in Bolivia (López et al 2011) which is of special reference here. In Bolivia the processing of the grains varies depending on the type of meal (either as whole seed, in soups or as flour). After harvesting and threshing, the grains are parched, trodden upon, winnowed, rinsed and rubbed, with different intensities and at different times, depending on the final preparation. Once the process is finished, the grains are ready for storing or cooking. During these enchained steps, seeds lose their pericarp and frequently their embryo, which would remain attached if the seeds were carbonized before their processing. In this sense, it is noteworthy that most of the documented *Corispermum* cf. *gallicum* seeds have lost both the pericarp and the embryo, so the edge of the seed presents a groove, except for the apex (Fig. 12.9e). Based on these characteristics, we hypothesize that the seeds of *C.* cf. *gallicum* were processed similarly to *Chenopodium quinoa*. Just 17 of the 385 remains preserve the pericarp and/or the embryo (Fig. 12.9c-d), so they could have fallen into the fire during the processing, probably during the parching. The fact that the majority of the remains lack the pericarp or/and the embryo suggests that they could have accidentally fallen into the fire during cooking before consumption, and after this processing had been completed (Fig. 12.9e). Moreover, 53% of the remains presents thermoalterations most of which are linked to high warming ratios, like swelling and protrusions, an observation that also supports our hypothesis that some type of processing with fire, such as parching or roasting, had taken place. Unfortunately, no tools related to plant processing have been documented in the site.

According to Power and Williams (2018), food processing becomes more frequent and intense in the course of the Upper Palaeolithic. This evolution is evident in the sequence of Cova de les Cendres, where the more abundant edible plant during the Magdalenian is a member of the Chenopodiaceae family that requires a complex process before consumption. In contrast, in the previous periods, the most frequent plant foodstuff was a fleshy fruit that can be consumed raw, that is the *Corema album* (L.) D. Don ex Steudel.

12.5.3 Portuguese crowberry (Corema album (L.) D. Don ex Steudel)

Corema album grows on sandy soils and coastal dunes of the Atlantic coast of the Iberian Peninsula. Moreover, a small and extreme disjunct population, consisting of 11 individuals, was documented in 1996 on the relict fossil dunes of the coastal cliffs of Serra Gelada (Benidorm, Alicante) (Fig. 12.5), and is evaluated as Critically Endangered based on the IUCN criterion D2 (Aguilella et al 2009). Hence, this species grows on areas from the thermomediterranean to the mesomediterranean bioclimatic belts and thermotemperate thermotypes, under dry-subhumid to hyper-humid ombrotypes (550 to 1600 mm annual rainfall), although in its Mediterranean location, annual rainfall is around 300 mm.

The Portuguese crowberry is a dioecious perennial erect shrub, densely ramified, up to 1 meter in height. Its whorled leaves are subpetiolate, linear, with a deep and narrow groove on the abaxial surface. Fruits are berry-like round drupes, 5-8 mm in diameter, white or pale pink, glossy, containing 1 to 3 pyrenes or stones with a thick woody endocarp (Villar 1993) (Fig. 12.11). Flowering occurs from March to April and fruiting from April to September.

The Portuguese crowberry has been considered a useful plant among the local people of the Atlantic coast of the Iberian Peninsula. Its slightly acid fruits are edible, and can be ingested raw or transformed into lemonades, liquors even jams (Gil-López 2011). They are a source of water, fibres and sugars, as well as of vitamin C, potassium and magnesium (Martínez-Varea et al 2019). Both leaves and fruit contain polyphenols and phenolic acids, and have medicinal properties as vermifugal, febrifugal, chemotoxic for carcinomas and neuroprotective against Parkinson's disease (Andrade et al 2017; León-González et al 2013).

In the Iberian Peninsula, *Corema album* remains have been identified in Early Neolithic, Chalcolithic, Phoenician, Medieval and Modern sites (López-Dóriga 2018), while the earliest evidence for its use comes from the Palaeolithic levels of Cova de les Cendres (Martínez-Varea et al 2019).

Throughout the Gravettian and Solutrean sequence of Cova de les Cendres various types of remains of *Corema album* have been recovered: mineralized and charred leaves, seeds and pyrenes (Fig. 12.11), accounting for 6839 remains, being charred pyrenes especially abundant in the Gravettian sequence (Fig. 12.10). At least, 3579 fruits were brought to the cave during the Gravettian, and just 16 during the Solutrean. On the contrary, no fragment of wood charcoal of Portuguese crowberry was identified among the anthracological assemblage.

Fruits of *Corema album* are available during summer, so they are predictable and easily gathered since no specialized tools are required: they can easily be knocked down into a container (Fig. 12.4). As previously pointed out, these fruits can be eaten raw, so they do not need any processing. This type of consumption, together with their simple harvesting, reduces the possibilities of generating archaeological evidence. However, their presence can be traced in the archaeological record, thanks to their woody pyrene, which must be thrown away during consumption. Hunter-gatherers could also have prepared some kind of beverage, with the pyrenes being probable by-products and thrown into the fire. In fact, some indigenous peoples of North America, as the Inuit, Inupiat, Cree or Ojibwa, consume the fruits of *Empetrum nigrum*, a species closely related to *Corema album*, fresh or cooked with animal fat (Anderson 1939; Porsild 1953, 21) or mixed with other berries to make pies and jelly (http://naeb.brit.org). *Corema album* berries could have provided the Palaeolithic hunter-gatherers of Cendres with vitamin C, as *Hippophae rhamnoides* L. did at Theopetra Cave (Kotzamani 2009) or at Balma de l'Auberador (Vaquer and Ruas 2009). At this point, however, we have to acknowledge that these are mere hypotheses, as we cannot prove the mode of consumption of the Portuguese crowberry berries in Cova de les Cendres, although human gathering is undeniable, considering that their natural habitat was 10 km away from the cave and that their presence varies along with other archaeological remains.

12.6 Conclusions

A diversified diet, including the ingestion of different types of foodstuffs -meat, fish, plant foods- is crucial in order to ensure the intake of all the essential nutrients at a sufficient level and to guarantee optimal human health (Lindeberg 2009). During the Palaeolithic a more or less diversified diet would have characterised hunter-gatherers; this diet would have included plant foods, as documented in different archaeological sites, like the Iberian ones presented here. These plant food resources would have provided them with fatty acids, vitamin C, minerals and proteins.

Complete control and management of fire was a "watershed moment" in hominid diet, as it opened opportunities of accessing, processing and consuming plant foods. The preservation of roasted pine cone bracts and nutshells with their original morphology provide evidence for an expert control of fire since resin is extraordinarily flammable and cones can quickly burn down. This ability to handle fire and to manage wild plant food resources is documented both among Neanderthals and modern humans since the by-products of Figueira Brava, Gorham's Cave and Cueva de Nerja are identical, thus indicating similar behaviour. Modern humans also applied this technique in the processing of other plant resources, as in the case of the seeds of *Corispermum* cf. *gallicum*.

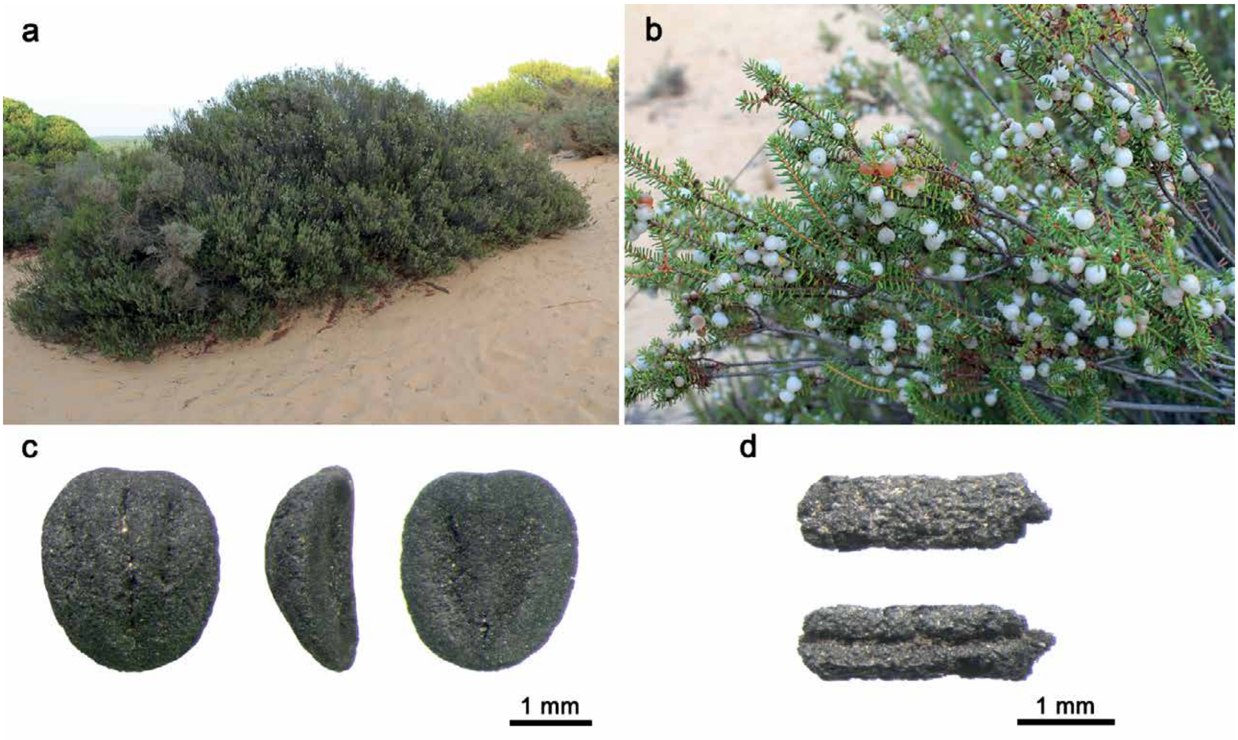

Fig. 12.11 *Corema album.* a plant; b fruit and leaves detail; c, d remains from Cova de les Cendres (c pyrene; d leaf).

In this regard, the presence of different types of remains and their characteristics shed light on the *chaîne opératoire* of plant food processing. Ethnographic and ethnobotanical information is essential in understanding the formation of archaeobotanical assemblages, together with experimentation, which is one of our future intentions.

The interrelation with plants and their exploitation led Palaeolithic groups to perform some kind of sustainable management of the fruit trees: they avoided the use as firewood of those species that provided food, despite the high calorific power of some of them; these are the cases of *Pinus pinea*, *Corema album* and *Corispermum* cf. *gallicum* presented in this work, as well as those of other taxa identified in Cova de les Cendres.

Coastal areas are extremely plentiful in resources, as they usually combine different biotopes. This biodiversity did not go unnoticed during the Palaeolithic (Real et al 2022; Will et al 2019) since several Middle and Upper Palaeolithic sites, like the ones presented here, are situated in such areas. In the Iberian sites in question, human groups would have made use of a diverse range of resources -shellfish, fish, mammals and plants-, like *Corema album*, *Pinus pinea* and *Corispermum* cf. *gallicum* that are discussed in the present paper. Experience provided Palaeolithic groups with thorough knowledge of their territory, of the life cycle of the useful plants and with the know-how that would have been transmitted from generation to generation.

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Chapter 13

Trends and evolution of the plant-based diet in prehistoric Iberia: a view from archaeobotany

Leonor Peña-Chocarro, Guillem Pérez-Jordà

Abstract

This paper offers a general survey of the transformation of the plant diet in prehistoric Iberia from an archaeobotanical perspective. The journey starts in 5500 cal BC when the first farmers arrived into the Iberian Peninsula bringing with them a set of cereals, legumes and oil plants, and it ends at the end of the 1st mill BC after Mediterranean traders introduced tree cultivation in Iberia. Focusing on the archaeobotanical record, this work highlights the profound changes that occurred in the diet and the agricultural transformation and developments that took place. To a lesser extent, general information is also provided on food preparation and cooking equipment highlighting the need for undertaking new fresh research into food remains which has the potential for breakthroughs in our understanding of food preparation and consumption.

Keywords: *archaeobotany, plant foods, Neolithic, Iron Age*

13.1 Introduction

The past thirty years have seen rapid advances in the field of archaeobotany in the Iberian Peninsula. There has been an increasing amount of publications focusing on plant foods from different chronological periods and subsistence systems. The greatest emphasis has been put on the Neolithic and the origins of agriculture (Peña-Chocarro 1999; Antolín 2016; Zapata et al 2004; Pérez-Jordà et al 2017a; Peña-Chocarro et al 2018), but other chronological periods have also been the focus of significant research. This is the case of the Bronze and Iron Ages (Stika 1988; Buxó 1997; Stika and Jurich 1998; Alonso 1999; Rovira 2007; Pérez-Jordà 2013; Alonso and Bouby 2017). Moreover, further topics have been added as the field has grown. For instance, research on the role of wild plant foods (Zapata 2000; Antolín and Jacomet 2015; Alonso et al 2016) or investigations on fruit cultivation (Pérez-Jordà 2015; Pérez-Jordà et al 2017b, 2021) which have given the field energy providing interesting insights into the plant-based diet of prehistoric and historic communities.

In an attempt to summarize how the plant-based diet in the Iberian Peninsula has evolved throughout time, this paper reviews archaeobotanical data on plant foods from different chronological periods spanning the Neolithic and the Iron Age. It discusses the 5500 years that have shaped the food habits of Iberian communities until the arrival of

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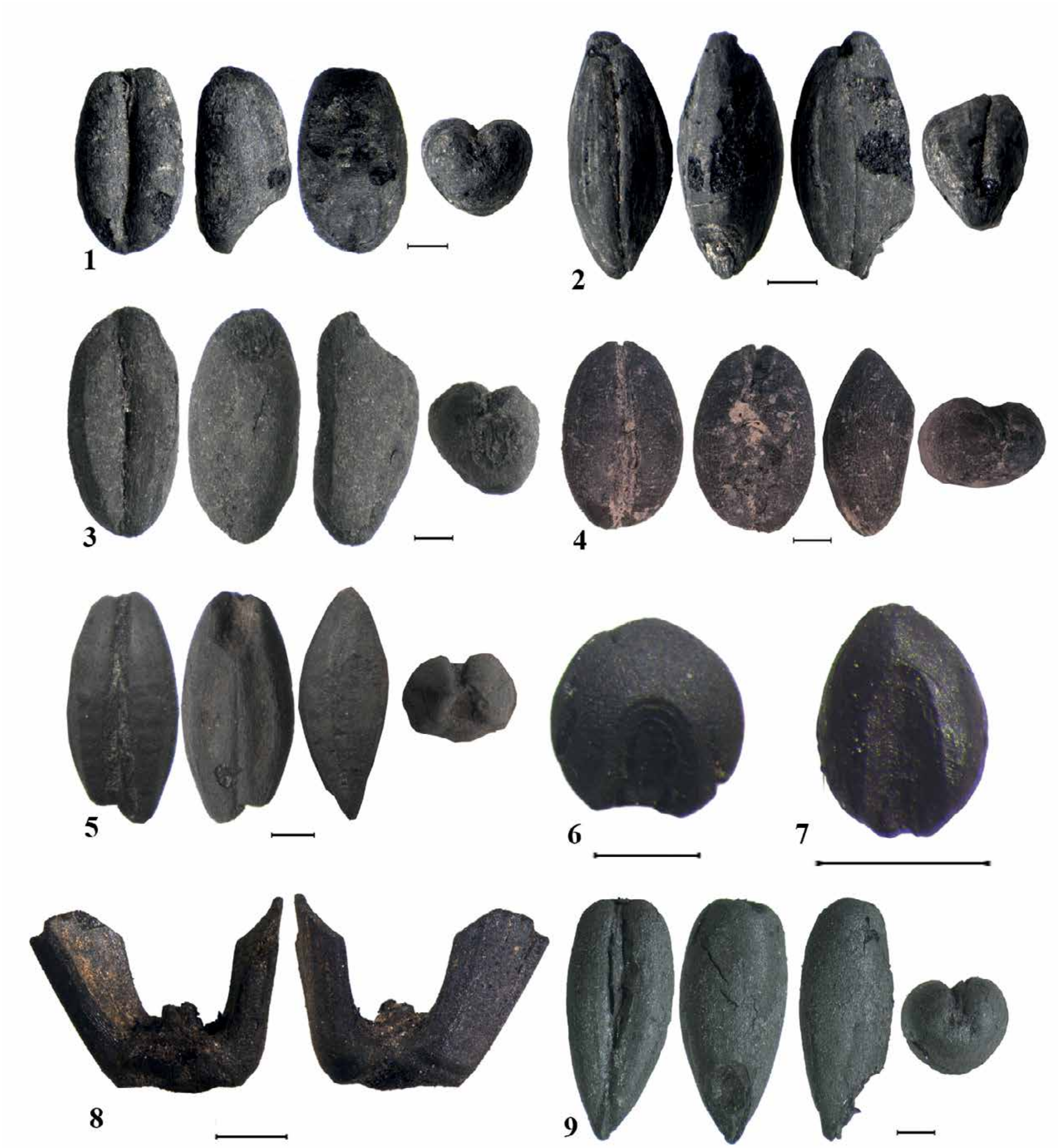

Fig. 13.1 Diversity of cereals identified in Iberia. 1 Bread/hard wheat (*Triticum aestivum/durum*); 2 Einkorn (*Triticum monococcum*); 3 Emmer (*Triticum dicoccum*); 4 Naked barley (*Hordeum vulgare* var. *nudum*); 5 Hulled barley (*Hordeum vulgare* ssp. *vulgare*); 6. Common millet (*Panicum miliaceum*); 7. Italian millet (*Setaria italica*); 8. Spelt spikelet fork (*Triticum spelta*); 9. Rye (*Secale cereale*). Scale bar= 1 mm.

Romans. Then, it explores some of the most important changes and transformations that have occurred in plant subsistence emphasizing the various introductions of crops that have taken place along the period, and it concludes with a reflexion on the current state of research.

This paper focuses on plant macro-remains while evidence from micro-remains such as phytoliths, pollen or starch grains has not been included. The archaeobotanical material considered here includes seeds and fruits that have been preserved by charring mainly. However, there are also waterlogged and mineralized plant remains but their frequency is much lower.

13.2 Origins and spread of agriculture: not only cereals

The study of plant foods has been largely concentrated on the origins of agriculture which has remained a central issue of prehistoric research. In fact, cereals have occupied a prominent position in any study of prehistoric subsistence. With agriculture cereals became staple foods providing most of the required individual energy and nutritional needs. In fact, remains of cereals (mainly grains but also chaff elements) are ubiquitous in archaeological contexts.

Along the 6th mill cal BC, the first farmers arrived into the Iberian Peninsula bringing with them a suite of plant and animal domesticates. They became established along the Mediterranean coast of Iberia and progressively spread inland. Different cereal species including both hulled and free-threshing cereals, several legumes and flax and poppy have been identified at the earliest sites. Einkorn (*Triticum monococcum*), emmer (*T. dicoccum*) and the so-called new glume-wheat recently identified as *T. timophevii* (Czajkowska et al 2020), all characterized by the presence of tight glumes attached to the grain, were the main hulled wheats. The only reference to the presence of the new glume-wheat comes from the sites of La Draga where a spikelet was identified (Antolín et al 2014) and Can Sadurní (Antolín and Schäfer 2020). Hard/durum wheat (*T. durum*) and bread wheat (*T. aestivum*) were the principal components of the so-called free-threshing wheat group in which the grain is easily freed from the glumes during threshing. A further cereal from this period is barley (*Hordeum vulgare*) which is also a significant element of the Neolithic plant-based diet (Fig. 13.1). Of all cereal species that were used during the Neolithic period, free-threshing wheats and barley were the most abundant and common. In contrast, hulled wheats were, in general during this period, less abundant with the exception of some sites such as Can Sadurní, Cova de les Cendres or Ambrona where einkorn and/or emmer have turned up as the predominant crops (see Peña-Chocarro et al 2018 and references).

Ethnographic data from different parts of the Mediterranean area (Hillman 1984, 1985; Peña-Chocarro 1996; Peña-Chocarro and Zapata 1999, 2014; Ertuğ 1997, 2004; Peña-Chocarro et al 2009; Valamoti and Anastasaki 2007; Alonso 2014, 2019; Moreno-Larrazabal et al 2015) has also supplied a wealth of information on the wide variety of cereal meals including bread and porridge-like products made of whole, cracked or ground grains, on their preparation methods and consumption practices. Experimental work has revealed fundamental to understand the different food categories. Bread-like foods are certainly at the centre of Near Eastern and European cereal meals, a tradition that recent research places back to the Epipalaeolithic in the Near East (Arranz-Otaegui et al 2018).

The first Iberian farmers also cultivated a great variety of legumes (Buxó 1991). Remains of at least seven species have been found: pea (*Pisum sativum*), lentil (*Lens culinaris*), broad bean (*Vicia faba*), grass/red pea (*Lathyrus sativus/cicera*), chickpea (*Cicer arietinum*), bitter vetch (*Vicia ervilia*) and common vetch (*Vicia sativa*), but their distribution across Iberia is uneven. There are regions like the Mediterranean and southern regions where pulses were common and others like the northern part where these were either absent or limited to a few species (Antolín 2016; Peña-Chocarro et al 2018). The number of pulse remains is certainly much lower than that of cereals, but legumes appear regularly in the archaeological record from the Neolithic onwards. Dried pulses could have been consumed in the form of boiled stews in the culinary traditions of the Iberian Peninsula. Legumes could also be added to cereal bread-like foods in times of scarcity as it has been ethnographically recorded. Moreover, the consumption of roasted seeds as snacks is also a common practice as well as part of religious festivities (Peña-Chocarro and Zapata Peña 1999). A popular way of consuming grass pea is in the form of a gruel (*gachas*) made of toasted flour mixed with garlic, water and meat. This preparation was widely consumed in many rural areas of the Iberian Peninsula during a large part of the 20th c. Today it has become a traditional dish in some areas.

Several species such as common vetch, bitter vetch and grass and red pea require detoxification due to the presence of neurotoxic compounds. In fact, in many cases these species have been considered fodder crops. By leaching out the toxic compounds by soaking the seeds in water, these species were suitable for human consumption. In fact, this was the common way of processing grass pea for human food in many regions of the Iberian Peninsula (Franco Jubete 2007). According to ethnographic information collected by the authors, in times of famine, bitter vetch was introduced in sacks and immersed into the river water so toxins were removed and the seeds could be eaten by humans.

The combination of the carbohydrates provided by the cereals and the proteins supplied by the legumes transformed these two categories in staples along the following millennia. Reconstructing culinary practices related to cereals and pulses based on the available archaeobotanical data is a complex task due to the difficulties involved in identifying the potential food remains and their ingredients. Recent methodological developments (González Carretero et al 2017; Heiss et al 2015, 2017, 2020; Arranz-Otaegui et al 2018; Fuller and González Carretero 2018; Primavera et al 2019; Valamoti et al 2019, 2021) are greatly contributing to a better comprehension of the ways prehistoric communities processed and cooked their plant food resources into more tasty and edible forms. This novel methodology includes a combination of macroscopic and microscopic observations using SEM in order to characterize the plant particles preserved in the surviving tissue fragments. In addition, the size and shape of the pores present in the mass matrix are recorded and compared to experimental reference material. This new approach is, thus, revealing most interested insights into food preparation and cooking processes.

Archaeobotanical research in the Iberian Peninsula has also identified amorphous fragments that on the basis of the latest findings could be cautiously interpreted as food remains. However, this type of studies are still little developed limiting our understanding of modes of food preparation and consumption. Of course, artefactual material, such as querns and grinding stones as well as structures tentatively interpreted as ovens, hearths and fireplaces, suggest some degree of complexity in food preparation during the Neolithic. However, it is also true that in most cases studies of micro-botanical remains from querns and grinding stones are missing as well as micro-wear analyses which impede to go beyond general considerations. Archaeobotanical data also provides support for cereal processing activities in order to obtain clean grain.

Wild fruits from different ecosystems such as acorns (*Quercus* sp.), figs (*Ficus carica*), wild olives (*Olea europaea*), wild grapes (*Vitis vinifera* subsp. *sylvestris*), hazelnut (*Corylus avellana*), mastic tree (*Pistacia lentiscus*), pine nuts (*Pinus* spp.), strawberry tree (*Arbutus unedo*), or *Rubus* spp. among others were gathered becoming part of the plant diet of Neolithic communities (Alonso et al 2016; Antolín and Jacomet 2015). In addition, other edible wild species from different ecosystems have been identified at several sites. These include species such as the nettle *(Urtica dioica*), bearberry (*Arctostaphylos uva-ursi*), fat-hen (*Chenopodium album*), edible oraches (*Atriplex* spp.), various members of the Rosaceae family (*Prunus* spp.) or caper (*Capparis* spp.) among others which could have been part of the human diet. From a nutritional point of view, wild plants provide a large quantity of vitamins, minerals, fibres and other important chemical micro elements that are beneficial for the human body.

With variations according to different factors and geographical areas, this assemblage of plant species was maintained throughout the Neolithic. As has been already stated (Peña-Chocarro and Pérez-Jordà 2022) the Bronze Age is a rather homogeneous period in terms of plant use. The only change is represented by the switch from hulled to naked barley which is observed by the Middle Bronze Age. This is a tendency also observed in some European regions (Stika and Heiss 2013). Nevertheless, the main Neolithic species continued to be used and no major changes are observed in the plant assemblages studied. So, for more than 4000 years, naked and hulled wheats and barley were the main cereals produced and consumed by the Neolithic and Bronze Age farming communities. By the end of the 2nd mill BC, however, the archaeobotanical record shows the first appearance of two new cereal species, the millets (*Panicum miliaceum* and *Setaria italica*) (Fig. 13.1) which later on, during the 1st mill BC, will spread across the Iberian Peninsula. Early examples include sites in the north-east (Alonso and Buxó 1995; Alonso 1999; Alonso et al 2002), and in the south of Iberia (Stika 1988; Peña-Chocarro 1999;). In Portugal, both species are also present during the second half of the 2nd mill BC (Tereso et al 2016; Jesus et al 2020). However, with the exception of sites (Alonso and Buxó 1995; Alonso 1999) where the number of caryopses of millet is abundant, in the remaining sites the presence of millets is just testimonial and never exceeding 10-15 caryopses. Nevertheless, gaps in the data prevent from recognizing the role of millets at the end of the Bronze Age. Such incidental presence would become firmly established during the 1st mill BC.

13.3 The 1st mill BC: new foodways

The 1st mill BC is a key period of change in terms of crop diversity as for the first time several new species appeared in the archaeobotanical record of the Iberian Peninsula. Both broomcorn or common millet (*Panicum miliaceum*) and Italian or foxtail millet (*Setaria italica*) (Fig. 13.1) spread during the Iron Age and their remains are mainly found in the north (López-Merino et al 2010; Tereso et al 2013; Teira Brión 2019; Seabra et al 2018, 2020) although millet use is attested as well as in other regions of Iberia (Rovira 2007; Pérez-Jordà et al 2017b). Both species are short-cycle cereals, which mean that their life cycles are completed between 60-90 days allowing farmers to obtain a harvest in a slack agricultural season. They are generally sown in the spring when the weather is warm, although millets are adapted to a wide range of climatic conditions. Ethnobotanical research in Spain (Moreno-Larrazabal et al 2015) provides information on the role of broomcorn millet in both animal and human food while foxtail millet is only used as animal feed. There is a wide variety of products made with millet flour which include bread, gruel, porridge-like food which are only obtained once the grains have been dehusked.

Other than the millets, a new species of hulled wheat, spelt (*Triticum spelta*), is recorded particularly in the northwest of Iberia (Fig. 13.1). Spelt is the main crop in the hilltop site of As Laias (Ourense, Spain), where massive storage of different cereal species has been detected (Tereso et al 2013) as well as in Crastoeiro (Portugal) (Seabra et al 2018) and Castelinho (Portugal) (Seabra et al 2020). The interesting point is that, in As Laias, spelt has been also identified in samples from the transition between the Bronze Age and the beginning of the 1st mill BC suggesting an earlier introduction. Spelt, together with emmer wheat

Fig. 13.2 Use of *mesorias* for harvesting spelt in Asturias (northern Spain) and plant of spelt.

(*Triticum dicoccum*), another hulled wheat, became important elements of the culinary traditions of north-western Iberia, and their cultivation has been maintained until the present day (especially that of spelt) in Asturias. Its cultivation is associated to traditional agriculture, the use of a particular tool for harvesting *(mesorias)* (Fig. 13.2) (Peña-Chocarro 1996, 1999, 2014) and the preparation of special bread that has occupied a specific market niche in the region (Peña-Chocarro and Zapata 2014).

A further interesting introduction in this period is that of rye (*Secale cereale*) (Fig. 13.1). The site of Crastoeiro (Portugal) has provided strong evidence of its introduction during 1st c BC when Roman influence in the area became stronger (Seabra et al 2018). From this period onwards, rye spread to other regions in Iberia, although the evidence suggests that it was mainly cultivated in the north of the Peninsula. This crop is well-adapted to cold marginal soils and winter temperatures and acid soils (Zohary et al 2012) where it produces excellent yields. These characteristics made of it a preferred species for the mountainous marginal areas of the northwest where it particularly thrived.

Among the legumes, chickpea (*Cicer arietinum*), a rather invisible crop in the archaeobotanical record spread in areas on southern and eastern Iberia. Like the other legumes, its consumption was probably boiled in stews, but it could also be consumed toasted as a snack. Interestingly, chickpeas were one of the commonest legumes used in therapeutic treatments in Antiquity (Kokoszko et al 2017). The remaining legumes are well represented in this period.

In terms of agricultural production, the 1st mill BC is also defined by the introduction and spread of fruit cultivation. This process is linked to intense inter-regional exchange networks in the Mediterranean area and thus is more evident in the southern coast where colonial encounters, particularly with Phoenicians, brought in new crops and novel agricultural techniques. From all the new crops such as almond (*Prunus dulcis*), pomegranate (*Punica granatum*), apple/pear (*Malus/Pyrus*), melon (*Cucumis melo*), grape (*Vitis vinifera*) and olive (*Olea europaea*), vines and olives reached particular importance (Fig. 13.3). Their derivatives wine and oil, also brought by the colonisers, were soon adopted by local communities acquiring a prominent role in their economies (Pérez-Jordà et al 2017).

Fruit cultivation had major impacts in agricultural practice. There were changes in the rhythms and cycles of farming as the new crops required new ways of management. Moreover, people established stronger ties to the land as the protracted cycle of production entailed protection and care of trees and plants for longer periods. But, the introduction of a larger variety of fruits in the diet also had beneficial effects in the nutrition of local communities as vitamins, sugars, minerals and fibres were incorporated into their diet (Bouby and Ruas 2014; Pérez-Jordà et al 2017b). Perhaps, the greatest success of the adoption of arboriculture was the development of an important market that was the ground of an intense and sophisticated exchange of goods and services.

A further point of interest is the production of iron tools (6th-5th c BC) which had an important role in agriculture.

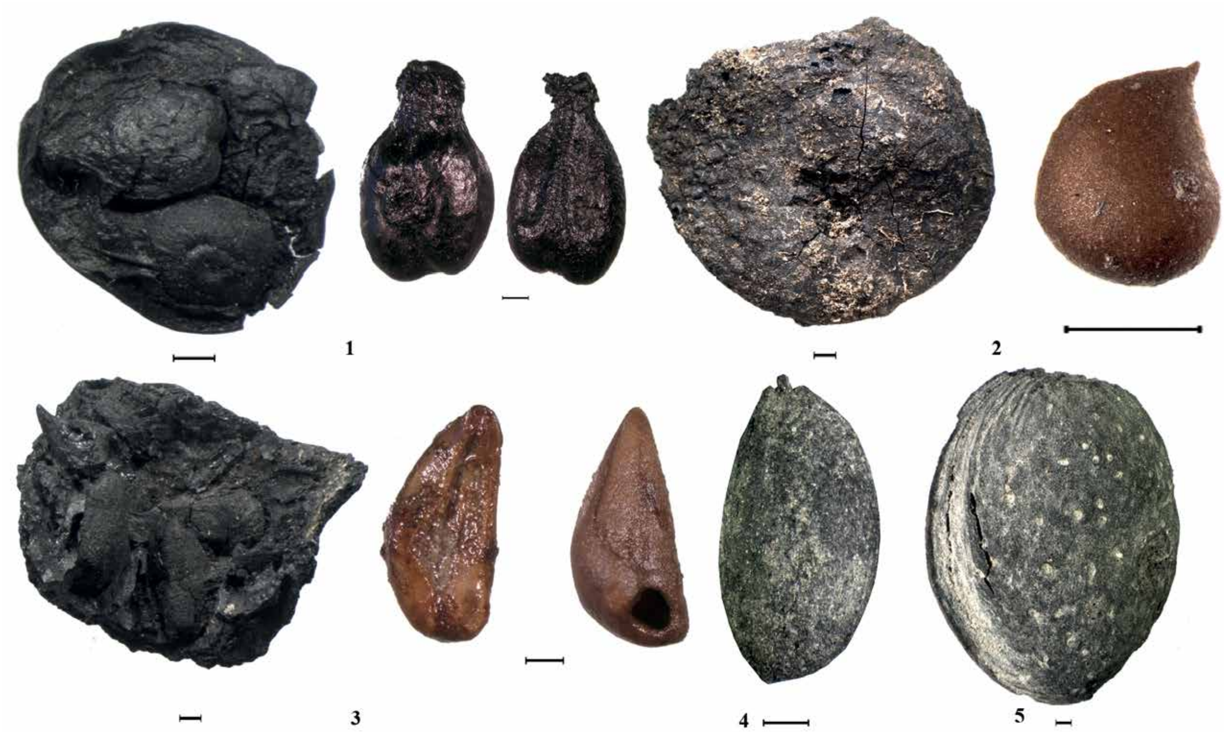

Fig. 13.3 Examples of fruit species (fruit and seeds) documented during the 1st mill BC. 1 Grape (*Vitis vinifera*); 2 Fig (*Ficus carica*); 3 Pomegranate (*Punica granatum*); 4 Olive (*Olea europaea*); 5 Almond (*Prunus dulcis*). Scale bar= 1 mm.

The presence of iron ploughs suggest the possibility of opening to agriculture areas hitherto cultivated. In addition, a wide range of tools e.g. ards, hoes, spades, picks, knives, billhooks, or sickles were created facilitating many agricultural tasks such as cereal harvesting, pruning or vintage among others (Pérez-Jordà 2013).

Cooking during the 1st mill BC is associated with different kitchen wares, among which the indigenous S-shaped cooking pot (often with lid) is the main representative together with the bowl for food consumption (Iborra Eres et al 2010; Buxó et al 2010; Vendrell Betí 2016). The cooking pot was primarily used for boiling to prepare broths or stews. Less common in indigenous settlements but rather usual in contexts related to Phoenician presence is the casserole, a further cooking pot, more related to baking or frying. Drinking and storage wares complete the ceramic assemblages. The archaeological record has also provided information of spits and grills and of a variety of cooking equipment such as hearths of diverse morphology, ovens and tannours, the latter in colonial contexts. Querns and rotary mills are also common in this period indicating processing activities related to the production of flour and other cereal products. In fact, from the 6th-5th c BC a new invention, the rotary mill is documented in Iberia. This new device which applied a rotary motion as opposite to the back and forth motion of querns implies a reduction in the time devoted to grinding (Alonso 2002, 2019; Alonso et al 2014). Most of this equipment is placed in domestic areas, but there are examples of large ovens as well that are suggested to be part of bakeries (Alonso and Pérez-Jordà 2019) or at least to have been used beyond the domestic sphere (Belarte et al 2016).

As said earlier, the 1st mill BC is a period of connectivity and circulation, of cultural and commercial exchanges, of hybridisation and evolving identities that transformed the communities living around the Mediterranean. New crops and food products such as wine and oil as well new spices of oriental origin such as coriander (*Coriandrum sativum*), and novel ways of cooking and consumption turned up in the daily life of Iron Age communities and appear clearly evidenced in the archaeological record. From their initial spread along the Mediterranean area these new foodways would soon penetrate into inland Iberia disseminating the novel products and their associated cultural practices. This profound transformation of the diet, cuisine and agricultural practices had major impacts in the ways of life of these communities and, in some cases, this process lasted until the arrival of the Romans.

13.4 Conclusion

Since the beginning of agriculture different crops of interest for human consumption have been introduced into the Iberian Peninsula. Early farmers brought in a varied set of crops (cereals, legumes and oils plants) while later on, during the 1st mill, different cultural groups translated to the Iberian Peninsula and other Mediterranean regions, a wide range of species (mainly fruit trees) originally growing in their homelands. Some crops such as barley, grass pea, *Vicia* spp. among others, may have had a role as animal food but the archaeological contexts that have provided these crops do not allow establishing if they were used for animal feed. Examples such as those coming from waterlogged contexts in England (Lodwick 2017) that have allowed identifying fodder remains do not exist in Iberia so exploring changes in the use of certain crops remains a rather difficult enterprise. Barley, for instance, has been widely used as human food up to recently so its role as fodder is difficult to spot. Moreover, examples of human consumption of species traditionally considered fodder plants exist in both the archaeological (Bouby and Léa 2006; Pérez-Jordà 2013) and ethnographic (Peña-Chocarro and Zapata 1999) records. In the case of true fodder plants such as alfalfa (*Medicago sativa*) the evidence from the period covered by this paper is very limited and raises numerous problems. It is likely that proper cultivation of fodder crops occurred only from Roman times.

Crops came together with traditions and technologies of food preparing and cooking that were also introduced in the territories where the new species were adopted. In addition, contacts with other groups broadened the list of species cultivated and cooking technologies. Their legacy was soon blended with further culinary traditions brought in by the Romans, Islamic populations and American communities that have all contributed to shape contemporary foodways. Food is a prism through which to view and understand various realms of human experience which encompass food strategies, technological changes, social interactions and power relations among others and as such it is a powerful tool to understand human history.

The archaeobotanical record of Iberia shows that Iberian communities consumed a wide variety of cultivated species that combined with wild resources (fruits, nuts, and other wild plants). However, data is still missing on the food products that were created and on the processes involved. Based on ethnographic information and evidence from material culture, it is assumed that different types of dishes would have been created according to different culinary traditions. Broths, stews, fried meals, dried and fresh fruit, bread, porridges and gruels were some of the ways plant foods were possibly prepared and cooked. However, the challenge for the coming years lies in the identification of food remains that will allow a more nuanced understanding of food ingredients, preparation and cooking methods and, therefore a more complete evaluation of food consumption. The comprehensive and detailed recording of the different types of food remains that are generally classified under very general categories appears as crucial starting point to approach the identification of different forms of food preparation (ingredients, routine activities) and cooking processes. Comparative collections of experimentally produced preparations become also an important issue as they provide a referential framework for advancing in this exciting topic.

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Chapter 14

Unearthing a new food culture: fruits in early modern Ireland

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Abstract

This paper will introduce an interdisciplinary research project that is seeking to understand the nature and meaning of food in Ireland during the sixteenth and seventeenth centuries. This was a period of increasingly globalised trade when new foods arrived into Ireland, some of which, such as the potato, eventually became dietary staples. Irish food cultures were also influenced by neighbouring Britain, which ruled over Ireland at the time, but some food choices seem to reflect more local traditions, such as the predominance of oats in certain social and economic contexts. Over the past two decades in Ireland, hundreds of archaeological excavations have unearthed food-related materials dating to the sixteenth and seventeenth centuries, including archaeobotanical and zooarchaeological remains, and artefacts, such as cooking and eating utensils. Much of the data relating to these finds resides in individual technical reports, however, and is considered on an individual site basis only. The ERC-funded “FoodCult” research project is addressing this issue through collation and analysis of archaeobotanical, zooarchaeological and artefact data from a wide variety of urban and rural excavations. New stable isotope analyses are being undertaken on human bone to discover dietary consumption, and new organic residue analyses of ceramics are finding out what foods they contained. These new archaeological and scientific analyses are being integrated with evidence from historical sources, providing a ground-breaking new approach to understand food and identity in a complex society. This paper will explore archaeobotanical and historical evidence, focusing on fruits, highlighting the challenges of an interdisciplinary approach, key gaps in knowledge, and how the FoodCult project is addressing these issues.

Keywords: *Ireland, early modern, archaeobotany, history, fruit, food*

14.1 Introduction

European food history has become a dynamic field and is increasingly regarded as a “*subject that sits at the heart of historical study and spreads right through its breadth*” (Kissane 2018, 2). New historiography is revealing the importance of the sixteenth and seventeenth centuries in terms of change. New foods were introduced through increasing international trade and intercultural contacts, and the growth of empires was accompanied by the emergence of “national” and more local concepts of foodways (Albala 2002; Thirsk 2007). The intellectual culture of humanism inspired new ways of thinking about what foods should be eaten (and avoided), how and by whom (Fitzpatrick 2017). Religious influences in this post-reformation society also influenced how food

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was conceived spiritually (Kissane 2018). These dietary changes played an important role in the development of many aspects of contemporary social identities.

In the case of Ireland, the study of archaeological evidence for food and diet during the last millennium is increasingly popular. Investigations often focus on evidence from archaeobotanical and zooarchaeological remains to provide insights into the plants and animals consumed and the social contexts for consumption (Beglane 2015; Lyons 2015). Studies of human bone, including stable isotope analyses, are undertaken to investigate the health of populations and dietary preferences (McKenzie et al 2020). There have also been studies of food-related objects, such as organic residue analyses that have provided unprecedented insights into the use of animal-derived products in particular (Smyth et al 2019). It is still the case, however, that there are relatively few archaeological studies of food dating beyond AD 1500, the end of the medieval period in Ireland. Although many archaeological excavations have uncovered food remains and food-related objects, and technical reports have been completed that detail the finds, a comprehensive review based on archaeological evidence is lacking.

This lack of archaeological investigation may reflect a perceived wealth of historical records relating to post-medieval/early modern Ireland (the term post-medieval is often used by archaeologists and the term early modern is more popular with historians; the term early modern will be used in this paper). There is an abundance of travel, ethnographic and satirical literature, for example, that recounts the experiences of visitors to Ireland at this time, including many hyperbolic and humorous representations of the foods consumed by different communities (such as Boorde 1547; Campion 1571; Derricke 1578; Payne 1579; Spenser 1576; de Cuellar 1588; Dymmock 1599; Camden 1607; Rich 1610; Moryson 1617; Gernon 1620; Brereton 1635; Dinely 1681; Dunton 1698). There is a dearth of detailed documentary evidence for actual diets beyond elite consumption, however. There are few historical records that focus on consumption patterns of the "Gaelic" or native Irish and their trade of foods with continental Europe. This may explain why historians have largely avoided detailed investigations into food in sixteenth and seventeenth century Ireland, which has meant that the study of food for this period has been somewhat neglected (Flavin 2014; Flavin et al 2021).

Instead, politics, warfare, colonisation and religion have tended to dominate historiographies for this period in Ireland (and wider Europe), which has resulted in far less attention being paid to the domestic sphere and the everyday, including foodways (Flavin et al 2021). There is also the impact of the Great Famine in Ireland, 1845-52, when a recurring potato blight and political mismanagement resulted in the death of hundreds of thousands of people through starvation, disease and large-scale emigration. The Famine has dominated food studies of early modern Ireland, resulting in a focus on basic subsistence practices and limiting investigations of cultural concepts to colonial narratives of exploitation and oppression (Barnard 2005, 17). But there is great potential for investigating intercultural aspects of food choices. There were significant levels of immigration during the sixteenth and seventeenth centuries, with people arriving from England, Scotland, Wales, France and the Netherlands. These movements of people reflected colonisation, conquest, trade and religious exile, and they resulted in unprecedented intercultural contacts, new settlement patterns and complex processes of acculturation (Flavin et al 2021). Food played a key role in identity formation, as indicated by the attention paid to diet in topographical descriptions, travel literature and colonial propaganda. Emerging national food cultures were not monolithic; regionalised food cultures are apparent within England, for example (Thirsk 2007). There were also global influences on consumption in Ireland, underlining the need to move beyond a passive portrayal of consumption driven by the Anglicising process (Flavin and Jones 2009; Flavin 2014; Flavin et al 2021).

Archaeology has the potential to provide insights into a greater variety of practices than allowed by historiographies (for example through incorporation of data from both high- and low-status sites), but a combined approach can make an even more significant impact on scholarship, as has been demonstrated in other European studies (Greig 1996; Badura et al 2015; Ruas et al 2017; Hondelink and Schepers 2020; Ros et al 2020). A new research project, FoodCult (Food, Culture and Identity in Ireland ca 1550-1650), is producing a deep, multi-layered perspective on this topic by undertaking one of the most detailed and interdisciplinary studies produced to date, funded by the European Research Council (Grant Agreement 803486) under the European Union's Horizon 2020 Research and Innovation Programme. FoodCult brings together an interdisciplinary team to establish the fundamentals of everyday diet, the cultural "meaning" of food and drink in early modern Ireland, and new insights into class, religious and gender identities as expressed through the consumption of food and drink. This is enabled through collating and merging historical and archaeological data, as well as undertaking new scientific analyses and experimental reconstructions. The project is investigating food through six related areas of scholarship: household accounts, food-related finds from archaeological investigations, experimental brewing, assessing nutrition through meat weights from zooarchaeological evidence, organic residue analyses of ceramic vessels, and stable isotope analyses of human skeletal remains (Flavin et al 2021). Initial results from the first two areas – household accounts and food-related finds from archaeological investigations – are discussed in this paper.

The household accounts include soldiery, institutional and elite accounts. Analysis of these accounts enable multi-scalar analyses, from the household (micro) to broader regional and societal trends (macro). The accounts help us understand how new types of foods were utilised and the occasions when luxuries were used. Some accounts record minute detail of provisioning arrangements and daily consumption patterns, revealing local markets, wages and prices, importation and local transport of imported foodstuffs and seasonal availability. The accounts also highlight social differences, such as elite versus lower-class consumption (servants and labourers), ritual patterns of eating including religious fasting, gift economies, and material culture relating to food preparation and consumption. FoodCult is also collating archaeological data from hundreds of archaeological excavations that have unearthed evidence from the sixteenth and seventeenth centuries, focusing on three categories of remains: plants, animals and objects. Data are collated on a context level, including finds of plant macro-remains, faunal remains and food-related objects (cooking vessels, processing and serving implements, etc). This approach enables investigation of food trends across time and space, and the comparative social, occupational, ethnic and geographical contexts in which foods were consumed. The archaeology dataset enables exploration beyond the ports and main centres of consumption (urban and more Anglicised regions) into areas where no documentary evidence exists, such as rural Gaelic Irish habitations in the northern and western parts of the country. Drawing upon initial historical and archaeological analyses, this paper will focus on one category of food – fruits – to explore its role in emerging food cultures. The paper will show how an investigation of different scales of data can help us better understand the complexity of the evidence and develop a more nuanced picture of foodways in early modern Ireland.

14.2 Fruits in focus

Assessing the role of fruits, and indeed vegetables, has always been problematic for historians in Ireland and Britain. It is traditionally believed that fruits played a minor role in sixteenth-century diet, especially among the wealthy. This assumption is related in part to contemporary medical dietary literature which was distrustful of these foodstuffs. In 1541, for example, Sir Thomas Elyot in *The Castel of Health* wrote that *"all fruits generally are noyfull to manne and do engender yll humours"* (Dawson 2009, 137). Likewise, *The Boke of Kervynge,* in 1508, warned the prospective servant to *"beware of green sallettes and rawe fruytes for they wyll make your soverayne seke"*. This assumption is also supported by the general dearth of references to fruits and vegetables in surviving household accounts from elite households, which record only marginal sums spent on these, relative to other foods purchased (Dyer 1983, 196). It is sometimes argued that the apparent lack of fruits and vegetables in the diet is a function of the type of sources historians rely on; that they may indeed have been available but were simply not recorded in household accounts because they often came from gardens or orchards attached to those households, rather than being purchased on the market. This is contested, however, as it underestimates the clear sophistication of accounting techniques (Dyer 1983, 195). Furthermore, it has been noted that on occasions where families were away from home and had to purchase all their foods, monies spent on fruits and vegetables were still negligible. While assessing levels of consumption in accounts is problematic, an even bigger issue is that these records are always biased towards wealthy households and institutions and tell us very little about consumption beyond that limited sphere. With these issues in mind, historians have contemplated the integration of archaeological approaches to extend their understanding of fruit consumption (Dyer 1983, 196), noting particularly the potential value of examining cess remains but, to date, there has been no major effort to undertake an interdisciplinary study.

This interdisciplinary approach is at the core of FoodCult. To increase our understanding of consumption practices, the project is simultaneously collating data from surviving household accounts, other historical records of consumption, and archaeological excavation reports. Archaeological data are currently being entered into a relational database to enable detailed analyses. At the time of writing, 127 distinct phases of activity (hereafter called sites) from 97 excavations had been entered, focusing on southern Ireland. It is expected that data collation and entry will continue for another year, incorporating sites from central and northern Ireland. Even at this early stage, initial querying suggests that this approach will significantly expand our ability to uncover social, regional and temporal patterns of consumption.

One of the food categories included in the database is fruits; locally grown and imported fruits that derive from trees and shrubs. The FoodCult dataset indicates that fruit seeds and stones are amongst the most common plant remains from urban archaeological sites dating to the sixteenth and seventeenth centuries. Whilst this will be interesting news to historians for the reasons outlined above, the discovery of a veritable "*fruit salad*" of remains at urban archaeological sites in later medieval Britain and Ireland is well known, whereby a wide variety and often large quantity of fruits are recorded (Greig 1981, 50; Lyons 2015). The reason for their regular recovery may reflect

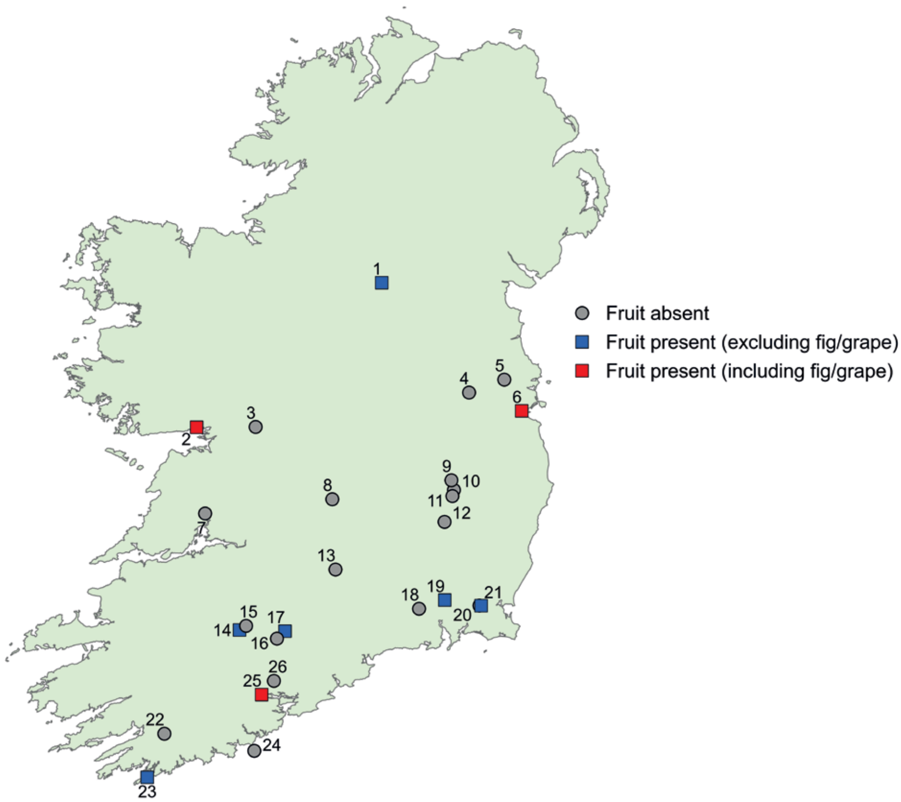

Fig. 14.1 Location of FoodCult sites that contained plant remains (sites currently entered into the FoodCult database). 1 Clogh Oughter; 2 Middle Street, Galway city; 3 Caraun More; 4 Garadice; 5 Killegland; 6 O'Connell Street Lower, Dublin city; 7 Clareabbey; 8 Rathnaveoge Lower; 9 Burtown Little; 10 Ballyvass; 11 Hallahoise and Woodlands East; 12 Ballybannon; 13 Gortmakellis; 14 Buttevant; 15 Kilcolman Castle (2 sites/phases); 16 Glanworth Castle; 17 Caherdrinny; 18 Ballykeoghan; 19 Camlin; 20 Bricketstown; 21 Harristown Little; 22 Castledonovan; 23 Franciscan Friary, Sherkin Island (2 sites/phases); 24 Old Head, Kinsale; 25 Grattan Street, Cork city (2 sites/phases); 26 Ballinvinny South.

taphonomy. Fruit seeds and stones are relatively robust and will often survive in well-sealed archaeological deposits where waterlogging has enabled preservation; such conditions are often encountered at urban sites in Ireland.

Although data collation is in the early stages, indications from the FoodCult dataset suggest a prevalence of fruit remains in cess deposits; this association between fruits and cess has also been noted elsewhere in Europe (Smith 2020; Ros et al 2020). The seeds and stones unearthed in these features represent the fruits eaten, digested and the seeds eventually excreted. The excreted material (cess) was then placed into pits (known as cesspits) or formal garderobes (toilets), as well as being incorporated more informally into watercourses, ditches, and other receptacles in towns. In many of the cess deposits, the plant remains have been preserved by waterlogging. The mode of preservation is important in relation to fruits. Fruits can be eaten raw, or if heated are likely to be mediated by a receptacle, such as a ceramic vessel. While recognising that fruit stones and seeds can be used as fuel, in Ireland it does seem that fruits were less often exposed directly to fire when compared with cereals dried over a fire before storage, for example. This may explain the relative scarcity of charred fruit remains, and it also highlights the possibility that fruits were often eaten raw. Again, this finding will interest historians, who query the consumption of raw fruits in this period, based on contemporary dietaries that stress the dangers of raw fruits, as outlined above.

14.3 Initial findings from the archaeological data

From the 127 sites currently entered in the FoodCult database, 29 contain plant remains (23%), and 10 of these contain fruit remains (8%) (Fig. 14.1). Five of these sites are urban, and five are not. The main towns and cities of this period in Ireland were coastal ports, and fruit remains were more often recovered at coastal or near-coastal sites, but there are finds from hinterland areas also. The non-urban sites include domestic settlements, an ecclesiastical settlement, a fortified stone-built house (known as a tower house in Ireland) and an industrial site (lime kilns). The fruit remains were present in a total of 14 features, most often in toilet-related deposits such as

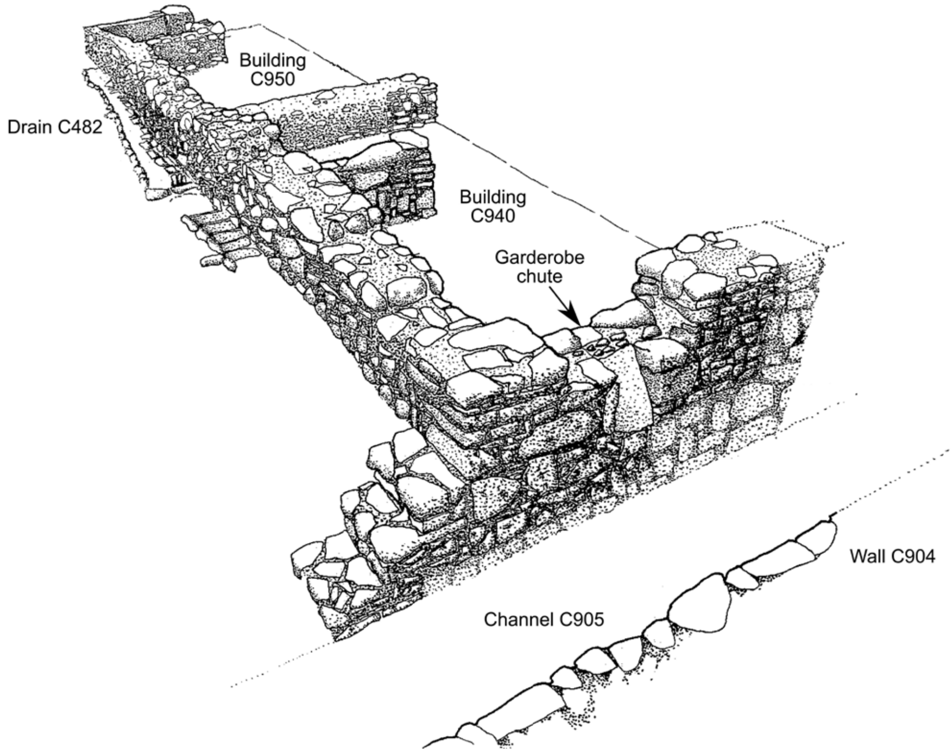

Fig. 14.2 Seventeenth-century dwellings and garderobe at Grattan Street, Cork (after Lennon 1993); the garderobe emptied into channel C905, which is where the fruit remains were recovered.

cesspits and garderobes, and pits and other cut features (wells, ditches, etc). Interesting questions are already beginning to emerge from these sites, particularly when examined in relation to the historical evidence.

It has long been apparent to historians that there was a market for imported fruits in Ireland during the sixteenth century, and before. Dried fruits – including figs, prunes, raisins and currants – have all been recorded as imports throughout the sixteenth century (Flavin 2014). The problem with the historical record, however, is that it rarely informs on the life of these fruits after their arrival at an Irish port. Occasional references in household accounts shed some light. In 1590, for example, the Lord Deputy William Fitzwilliam paid, on numerous occasions, for the transport of sugar, figs, and other fruits from the port at Waterford to Dublin Castle, but beyond these references, there is very little detail available on the diffusion of imports (Fitzwilliam Manuscripts (Irish), Northamptonshire Record Office: 30). Furthermore, as noted previously, locally grown produce tends to be poorly recorded in records. Initial findings from archaeological evidence, albeit based on a small dataset, are beginning to develop this picture and illuminate the relationship between the local and global in this context.

It is notable that the urban archaeological sites contained a variety of fruit remains, including *Ficus carica* L. (fig), *Vitis vinifera* L. (grape), *Fragaria* spp. (strawberry), *Malus sylvestis* (L.) Mill. (crab apple), *Prunus spinosa* L. (sloe), *Prunus* spp. (cherries), *Rubus fruticosus* L. agg. (bramble), *Rubus idaeus* L. (raspberry) and *Sambucus nigra* L. (elder). Non-urban sites contained a far narrower suite of remains, comprising only bramble/raspberry and elder. Almost all of the fruit remains from urban sites were waterlogged. By contrast, none of the fruit remains from non-urban sites were waterlogged. Archaeobotanical studies have highlighted how the types of food plants recovered can be strongly correlated with the mode of preservation (Colledge and Conolly 2014; Hondelink and Schepers 2020). Charring tends to favour plants more likely to come into contact with fire (such as cereals being dried), while waterlogging is less discriminatory. In the case of the FoodCult sites, it is likely that waterlogging enabled preservation of a wider variety of plant species at urban sites, including fruits, rather than fruits simply being more easily available to urban communities.

Of the 10 sites with fruit remains, a couple are interesting for comparative reasons. Two seventeenth-century waterlogged cess pits at Middle Street, Galway contained a significant volume of fig seeds (>1000), as well as a small quantity of bramble, grape, strawberry and *Prunus* (Clyne 1988). In contrast, a seventeenth-century waterlogged garderobe deposit at Grattan Street in Cork contained mainly bramble, elder, sloe and apple, with only occasional fig (Fig. 14.2; Lennon 1993). Of course, straightforward comparisons are problematic. It would be tempting to suggest that the Galway cess pits represent the toilet facilities for an elite community in Galway (where exotic, imported fruits such as fig and grape are prevalent), and the garderobe in Cork was used by a lower-class community (where presumed local fruits are prevalent). It could also be inferred that given Galway's extensive but unquantifiable trade links with Iberia, exotic fruits were more prevalent there. A contextual approach provides a more nuanced view. One cess pit at Middle Street, Galway contained most of the fig and all of the grape remains, but the other cess pit contained mainly bramble seeds with occasional fig and strawberry, much like the Grattan Street garderobe deposit. Furthermore, >1000 fig seeds might seem like a large quantity, but even a single fig fruit can contain hundreds of seeds, which means that fruits producing large numbers of seeds can be overrepresented in the archaeobotanical record (Hondelink and Schepers 2020). These issues highlight the need for a contextual approach that takes taphonomic factors into account.

14.4 Merging history and archaeology: possibilities and challenges

The archaeology results become even more interesting when integrated with the historical sources. The presence of fig and grape at coastal, urban sites (Fig. 14.1) is notable because Ireland's climate is not well suited to the growing of these two fruits. Fig, for example, can ripen in Ireland, but the fruits tend to be parthenocarpic, in that they produce fruits without fertile pips (Dickson and Dickson 1996). While fig and other exotic fruits may have been grown occasionally in gardens, it is unlikely that a substantial and reliable harvest could have been achieved. For market requirements, it is likely that these fruits were imported, perhaps originating in France or Iberia, and arriving in Ireland with other products. This appears to corroborate the historical evidence showing the importation of these fruits in the sixteenth century. Further though, it helps illuminate, in new ways, the relative trade networks of various regions. Urban sites in Cork that contained exotic fruit remains also contained a variety of Iberian ceramics (including Merida-type, Iberian Starred Costrel and Seville olive jars) and French ceramics (including Beauvais earthenware, Late Saintonge and Martincamp). As there are few historical records of Cork's direct overseas trade beyond England in this period, this gives a sense of the context of these imports otherwise unavailable. Further, though, it should be noted that integrating history and archaeology can also help complicate our understanding of access to what appear to be more prosaic local fruits. The presence of apple in the Cork garderobe, for example, could reasonably be assumed to reflect consumption based on relatively local stands of vegetation, and therefore, perhaps less engagement with globalising trends. Examining this in the context of historical sources suggests this assumption would be a mistake. Trade records indicate the importation of apples in sixteenth-century Ireland (Flavin 2014, 180), demonstrating that just because a fruit can grow locally, we should not automatically assume this was the case. Ros et al (2016, 135) have noted a similar situation in medieval Catalonia, where figs were both grown locally and imported. In Ireland, many new varieties of native fruits appeared in the later sixteenth century and these may well have been imported to broaden local tastes and demonstrate engagement with changing fashions. In some cases, therefore, the archaeological remains of apples may reflect imported produce available only to certain social classes or prized specimens from formal orchards (see below for further discussion of orchards).

Other trends can also be examined through an interdisciplinary perspective. Historical records, while limited to certain establishments, are useful for indicating temporal changes in fruit consumption, illuminating both changes in attitudes to fruit, but also seasonal changes resulting from cultural associations and availability. It has been noted, for example, that while attitudes to fruits were quite negative in the earlier part of the sixteenth century, new ideas and fashions increased the status of fruits and vegetables from the later part of the century (Thirsk 2007; Gentilecore 2015, 115-132). Historical records indicate that the cultivation and consumption of different fruit varieties and species in early modern Europe became an important means of communicating social differences (Grieco 1999, 312). Fresh engagement during the Renaissance with ancient philosophical ideas such as the Great Chain of Being, which ordered foodstuffs hierarchically, and placed high-growing fruits in the top tier of plants, led to an association between certain fruits and noble consumption (Grieco 1999, 307-309; 2020, 159). Italian poets in this period even dedicated poems and sonnets to fruit, reflecting the importance placed on fruits as a symbol of wealth and power (Grieco 2020, 156, 159). Meanwhile, trade generated a new awareness of various types of seeds and plants, and the status of gardening was gradually raised, encouraged by an increasing interest in the science of horticulture (Thirsk 2007).

In Ireland, there is broad evidence of an increasing interest in gardening amongst wealthier members of society during the sixteenth and seventeenth centuries (Thirsk 2007, 296; Flavin 2014, 168). New and improved varieties of fruits were introduced, accompanied by improved cultivation, and fruits played an increasingly important role in new food cultures. At the same time, a new enthusiasm for the establishment of orchards emerged, led by the wealthy Irish mercantile elite.

Fig 14.3 The Irish Pitcher variety of *Malus pumila* Mill. at the Lamb-Clarke Historic Irish Apple Collection, University College Dublin. This is a heritage orchard containing >75 varieties of apples grown in Ireland decades and centuries ago.

Orchards were certainly present in sixteenth-century Ireland, but they began to feature more prominently in historical accounts from the early seventeenth century (Barnard 1990, 73; Ó Drisceoil 2008; Flavin 2014, 169; 180). Although we should be careful not to overemphasise the impact of colonisation on Irish food consumption, some trends were driven by new arrivals from England. This was the "plantation" period when communities were transplanted to Ireland from England by the ruling English government. Arrivals in Ireland were sometimes granted land leases that required "land improvements", including the planting of fruit trees and development of orchards (often dominated by apple trees). Some southern towns such as Youghal and Bandon came to be characterised by dense orchards, reflecting the concentration of planters here (Barnard 1990, 73). These orchards required significant management, as indicated by the reduction in orchards by the later seventeenth century due to the impact of wars, whereby orchards were destroyed or neglected (Barnard 1990, 73).

Evidence for the impact of these changes and the increasing status of fruits is also found in household accounts, which although scarce, can help to identify temporal trends at a very detailed level. Comparing two accounts from Dublin Castle in the 1570s and 1590s suggests that even within that small timeframe, significant changes may have occurred. In 1570, the consumption and range of fruits and indeed vegetables is negligible. In 1590 this is entirely different. In that year, a significant £7 was spent on fruits and vegetables, and numerous fashionable new plants are recorded, such as skirret and artichoke. The account shows that 10*s.* (shillings) 4*d.* (pence) was spent on seeds for the gardener and that Lady Anne, the Lord Deputy's wife, was keenly involved in the process. This change is also reflected more broadly; there are increasing references to gardening practices in seventeenth-century Ireland. In the late 1660s, a landowner in the east of Ireland provided instructions to his gardener on the care of strawberries, while gooseberries, melons, grapes, figs, nectarines, peaches, apricots, and oranges are mentioned in seventeenth-century texts (Barnard 1990, 75-80). At least some of these may have been grown in glass houses and their cultivation regarded as a fashionable accomplishment. On occasion, records give a sense of the large number of varieties of a single species of fruit. A household account from Castlemartyr in Cork, dated to ca 1670, lists six different varieties of cherries and an impressive 20 varieties of plums (Orrery Papers, Petworth: MS 13; 193). New varieties may have been targeted because they were tastier, sweeter or had a more pleasing shape than those available in Ireland. This extraordinary diversity evident at Castlemartyr has not yet been detected in the archaeological record because standard archaeobotanical methods identify fruits to genus/species level rather than variety. Scientific techniques have recently been developed, however, to explore landraces and varieties of individual species, including geometric morphometrics (which involves detailed analysis of seed shape and dimensions) and aDNA (Terral et al 2010; Burger et al 2011; Bouby et al 2013; Cornille et al 2019; Bonhomme et al 2021); application of these approaches to Irish material could enable new findings on varietal preferences and agrodiversity.

Broadly speaking, the consumption of these fruits was seasonal. A sample year of household accounts from Dublin Castle in 1574, for example, records that apple purchases were restricted to September to March, highlighting the seasonal availability of some fresh fruits (Fitzwilliam Manuscripts (Irish), Northamptonshire Record Office: 51; Flavin 2014, 180). This too was changing, however. Sugar, found in elite records from the late-sixteenth century, was increasingly used to preserve fruits, thus increasing the availability of out-of-season and imported fruits, as well as making sourer fruits more palatable (Thirsk 2007, 295).

Further historical evidence of the increased status of fruits is its appearance on regular occasions in the later-sixteenth century as a gift amongst elites. Provisional analysis of an account for 1590 shows numerous entries in the records of Dublin Castle for gifts of fruits specifically given to her ladyship. Strawberries were brought on numerous occasions along with pears and quinces (Fitzwilliam Manuscripts (Irish), Northamptonshire Record Office: 30). The frequency with which these items are repeated in the account suggests that these were varieties now produced locally, probably in the orchards and gardens of the better-off. More exotic fruits were also gifted. In the same year, the Mayor of Waterford sent Lady Fitzwilliam oranges and sucket (preserved fruit), and the Mayor of Dublin sent oranges and lemons. The fact that these were considered a suitable gift between elites shows their value and rarity. Interestingly, however, there is also evidence of the gifting of more familiar types of fruit, again perhaps indicating the overall changing status of fruits. During the seventeenth century, historical records indicate that tenants of Lord Cork gathered apples as Christmas gifts (Barnard 1990, 73).

14.5 Conclusions

It is clear that the historical record can inform, in many new ways, on the changing nature of fruit consumption in the early modern period. It can provide archaeologists with information not available in the archaeological record, such as the variety of specific fruits, seasonal variations in consumption, temporal changes in fashion and the cultural significance of fruits in mediating social relationships. It can only do this from a limited perspective though, under-representing the types of fruits consumed overall and reflecting practices at a limited range of atypical establishments. Integrating this material with archaeology can benefit both fields. By mapping the species of fruits recorded from archaeological excavations across space and time, and relationships to other types of food-related remains, the FoodCult team is able to explore the nature of consumption from a much broader perspective and develop a better understanding of the social and geographical significance of these changes.

This paper has reviewed initial results from only two areas under investigation for the FoodCult project: historical household accounts and food-related finds from archaeological excavations. Implementation of a broader suite of analyses will further develop our understanding of food cultures in early modern Ireland, including organic residue and stable isotope analyses, experimental brewing and assessment of meat weights. When combined, these approaches will shed light on the myriad of factors that influenced diet – including social class, religious belief, gender, globalisation, ideological trends, environmental factors and market access – whilst helping to ameliorate the limitations of discrete analytical approaches, thus providing a research model that can be applied far beyond early modern Ireland.

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Chapter 15

Let nothing go hungry: the indigenous worldview of Andean food and feeding

Christine A. Hastorf

Abstract

Up until 2000 years ago most people around the world believed and engaged with their landscape in an agentive way, all parts of the landscape interacted in their surroundings. People thought that everything was a subject not an object, that plants, rocks and streams were sentient and agentive. The Andean indigenous ontologies propose that the people who live in that landscape are responsible for all other beings, including plants, animals, water, and rock. This includes both the fields of planted domesticates as well as the wild plants. Archaeologists are learning that, as people settled down on their landscape, they valued not only their beloved domestic animals and plants but also the wild beings that resided throughout the landscape. These beings are not just part of the ecology of a vibrant ecosystem, they are also beings that form a more diverse communicative world for those that live there. People therefore must not only tend their domesticates, they also watch and engage with the wild plants, tending them as well. This paper presents the Andean indigenous world view of the altiplano farmer and how they feed many throughout their environment. This approach can help us think about the longue dureé of food systems not only in this stable environment now and in the past but in other settings.

Keywords: *Andean ontology, feeding, reciprocity, sustaining*

15.1 Introduction

We love food. We are content when we eat it daily, and really must eat it weekly to remain alive. Each of us thinks regularly of what we want to eat and how we will gain that. When we have recently eaten, we feel replete, calmer, happier in the world. When we are hungry the opposite is true, we are upset, anxious, and unhappy. It is not surprising that organic oriented archaeologists have gravitated to asking about past foodways, as we investigate the remains of the daily meals in contexts throughout the world, striving to learn about daily tasks and goals of the many that have lived on this earth before us. The PLANTCULT project is a wonderful example of this aspiration. Working hard to improve methods so we can better address questions not only about food production, processing, the technologies of those actions, what these methods look like in the archaeological record, but also about menus and meals and what these culinary traditions might have meant in the place and time of their creation, consumption and deposition. Eating and being fed are core to these archaeological research questions. Just as parents want everyone in their family to be well fed, it turns out, some worldviews extend this sated concept beyond the children, parents and grandparents that surround the family hearth

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and table, to every being around them throughout their landscape. Much like the concept of interconnectedness of all living things within ecosystems, the indigenous ontologies of the Americas extend this concept of feeding all things across their landscape, to insure a balanced, contented environment as well as household. In this worldview, the family cannot be nourished if these others around are also not fed. A hungry landscape is an unhappy one, making all who dwell in it worse off. This is the aspect of food ontology I want to present here, opening up the concept of food and feeding by thinking about this aspect of feeding beings throughout the landscape, keeping the environment and all of its residents' content and replete, and therefore in balance. Such a worldview is not just a useful ecological model it also has real empathetic value, it moves people to extend their care to more things in the world than themselves. This is a concept that could be good to think with both for our studies of the past but also for today's world as well. It extends the concept of food and feeding out into the landscape, resonating with Ingold's work on indigenous ontologies of the north of dwelling, place and meaning (1993, 2000).

Across the Americas, indigenous societies have demonstrated long-term sustainability configured by this sentient ontology. These indigenous ontologies require attention to many contexts in order to grasp the web of relationships among land, living beings, and people. As anthropologist David Walsh states: "Indigenous ontologies are predicated on a relatable world wherein indigenous peoples directly engage with the environment and living beings within the environment, thus avoiding the Cartesian dichotomy of nature and culture prevalent in modern Western worldviews" (2015, 231). This is a religion of *this world*, centering on the social relationships among people, plants, animals, water, and land; all are sentient beings engaged with watching, and caring for those around them in a mesh of give and take. This world is also a spiritscape whose beings also must be well-nourished.

This brings me to archaeology, and how we can engage with the foreign worlds of the past. How do we get into another's mind and activities to gain a better sense of their life and ways of coping in their world? It seems hard enough to learn about what people actually did in the past, what their actions were, let alone their motives, but by turning our attention to assuming these worldviews could have operated, we gain a new sense of the resilience of people in the past. We can ask – What was the food for the different beings throughout the landscapes we study?

15.2 Indigenous Ontologies

Descola (1996), Viveiros de Castro (1998), and de la Cadena (2015) are our intellectual interlocutors on this project of Andean indigenous ontologies of landscape, food and feeding. What would we do if we took Viveiros de Castro charge seriously when he presses us to take native thought seriously? As Holbraad comments, "What would happen if the native's discourse were to operate within the discourse of the anthropologist in a way that produced reciprocal knowledge effects upon it?" (2013, 475). With such a question, he urges anthropologists and archaeologists to think about the consequences of explaining, interpreting, and contextualizing our archaeological endeavors from a native point of view, while addressing the possibility that, in dealing with others' alternative worlds, what may arise could be views other than those anticipated by the analyst. Important in this approach is not to make direct links between the past and the present but to actively question what we think we know about the past and the reality of our constructions of it (Haraway 1988; Latour 1993). We are not looking for specific truths about the past, but to increase our vantage points of it, becoming more aware that we are constructing situated knowledge of histories and lifeways of people and beings (Haraway 1988). This requires us to resist the practice of translating indigenous knowledge into our own categories but to engage with other ontologies, as an opening to native (or other) forms of living in the world that first, provides information about indigenous landscapes in their own right but also will alter our conceptions of engagement, landscape, and food to the extent that the resulting (relational) differences will demand reconfiguring our own interpretations.

In these American worldviews, all beings require and desire sustenance, they want to be noticed, cared for, and fed (Bolin 2010). This has been expressed in many different ways in the literature, but here I will focus on the gifting side of this rich and diverse ontology. Gifting in this sense is recognizing these beings that live throughout the landscape and giving them recognition by offering them food. This "food" can come in many forms: a statement, a song, an offering, a thought, human food, or smoke. These offerings nurture and feed these beings who receive them (Kimmerer 2013). Being fed and recognized by those who stop and engage with them, they feel nourished and tended and in turn give to the gifter. This is how native people hunt animals, collect plants, net fish, and grow crops. During this process, gifts are given as part of a request for something in return- a reciprocal interaction. This is how springs contiue to flow and rain falls from the sky. A concept noted by many indigenous scholars accompanying the concept of feeding beings throughout the landscape is also that there should always be enough food to feed all beings, noted in the phrase "Let nothing go hungry". This translates to gatherers and farmers leaving some of the harvest in their gardens, fields, lakeshores and forests for the other beings, who also need to gain their sustenance from that same landscape. Kimmerer notes how to gather leeks appropriately; one must take only enough for the meal while leaving enough to avoid the disappearance of the ingredient. This requires using certain harvesting strategies that are non- destructive (Kimmerer 2013, 78). There is enough food for all because of this empathetic, ecological, approach to the world. Such practices might not look to be the most efficient, but will be more sustainable, allowing for resilience over time. While these conceptual engagements exist throughout the American continents, they are common in many animistic groups around the world, and could have operated globally to some extent for many millennia. Our job is to seek them in examples where we see resilience.

15.3 Andean Ontology

To initiate this, I want to focus on the region I know best, building upon both archaeological and ethnographic fieldwork. The archaeological project I have been involved with since 1992, the Taraco Archaeological Project (TAP), studying a peninsula in the altiplano of Bolivia, has begun to engage with local ontologies as an opening to indigenous forms living in that landscape, requested by the residents of Chiripa, as a project to record their elders. These residents received their land from colonial haciendas in the 1953 Bolivian agrarian reform and have continued to farm, herd and fish within a traditional food systems mode, where they grow most of the food they consume themselves, selling some for cash (HLPE 2017). In 2017 and 2018 two teams of three interviewed and recorded 45 residents of the community, mainly elders as requested by the community, but also other residents when available. These were open ended interviews, where we asked individuals to talk about and show us where they went to complete daily tasks, telling us about what was important about them. We recorded what they said, where we were, as well as putting a gopro on their hats to record the place from their vantage point. Often walking to locations, this provided indigenous landscape information about agriculture, collecting, and tending in its own right but their descriptions and comments also outlined their engagments with their landscape on other, non-tangible levels. This began to alter our conceptions of past engagements with the landscape and spiritscape, rethinking about what the associated material manifestations could be. Their descriptions and stories illustrated a relational way of engagement. The core agentive elements are enacted through reciprocity; gifting and feeding. This reciprocity between beings allows for flows between things to sustain and nourish all involved. This makes for a range of engagement within these landscapes that are simultaneously also spiritscapes, as some beings are not visible to people's eyes. These recorded interviews called for the reconfiguration of our approaches and interpretations, not only to the present but also the past. While such an approach is not new when studying traditional resource and environmental management (TREM) (Lepofsky 2009), we were not seeking to gather yield or timing information but rather how they, in their own words, wanted to talk about their landscape and what they did there.

The Andean region of western South America is a place where rituals surrounding agricultural production and food have been well-documented (Allen 2012; Isbell 1978; Salomon 2018; Siller 2009). The rituals surrounding preparation and planting are especially important to assure successful growing seasons. While particular rituals vary from community to community, they almost always entail some offering of prayers, coca, food, and even blood to water/clouds, stone, field and land. Early Spanish chroniclers describe planting and harvest rituals conducted by the Inka. It is likely that these were then very old actions, as people spread across the American continents and began to reside on the landscape with an increased focus on local plants and animals, they continued to make offerings to the land and all its beings to keep food available for all.

Rituals and offerings are key to maintaining the relationships between human and non-human actors; de la Cadena (2015) names these participants "earthbeings", forged through agricultural production practices, they carry the life force that animates. These beings are considered to be guardians of people but only if they are recognized and attended to by them. Offerings are most often made to the earth-being, *Pachamama* (mother earth), whose soil is manipulated and modified in order to produce food that will nourish the human community as well as other beings, such as birds and rodents. The success of the harvest rests in the hands of these earth-beings, located throughout the landscape, such as the mountain-peaks, rock formations, springs, and where two streams come together. Such watery places can influence the atmosphere and the sky by way of clouds, particularly rain (or lack thereof), frosts, and the possibility of damaging hail. A central player in these engagements is water. Water incubates generative forces as it flows out of mountain springs and embodies ancestral persons (Janusek 2020, 95). Flowing water carries messages and power. Liquid is often offered as gifts to canals, streams, and the earth, making irrigation a form of feeding plants and beings.

Catherine Allen writes elegantly about how Andean stone formations, springs and places in the landscape are in reciprocal relationships with other elements, fields, places, birds, animals, plants and people (2016, 338-339). To maintain themselves, these beings must be fed, recognized and engaged with. These obligations are inescapable to successfully live in the world (Bolin 2010). The mountains, springs and rocks embody animate ancestral forces that are important to the well-being of people, plants, crops, animals, and herds. Feeding the landscape in turn feeds the people, keeping both vibrant. This interconnectness

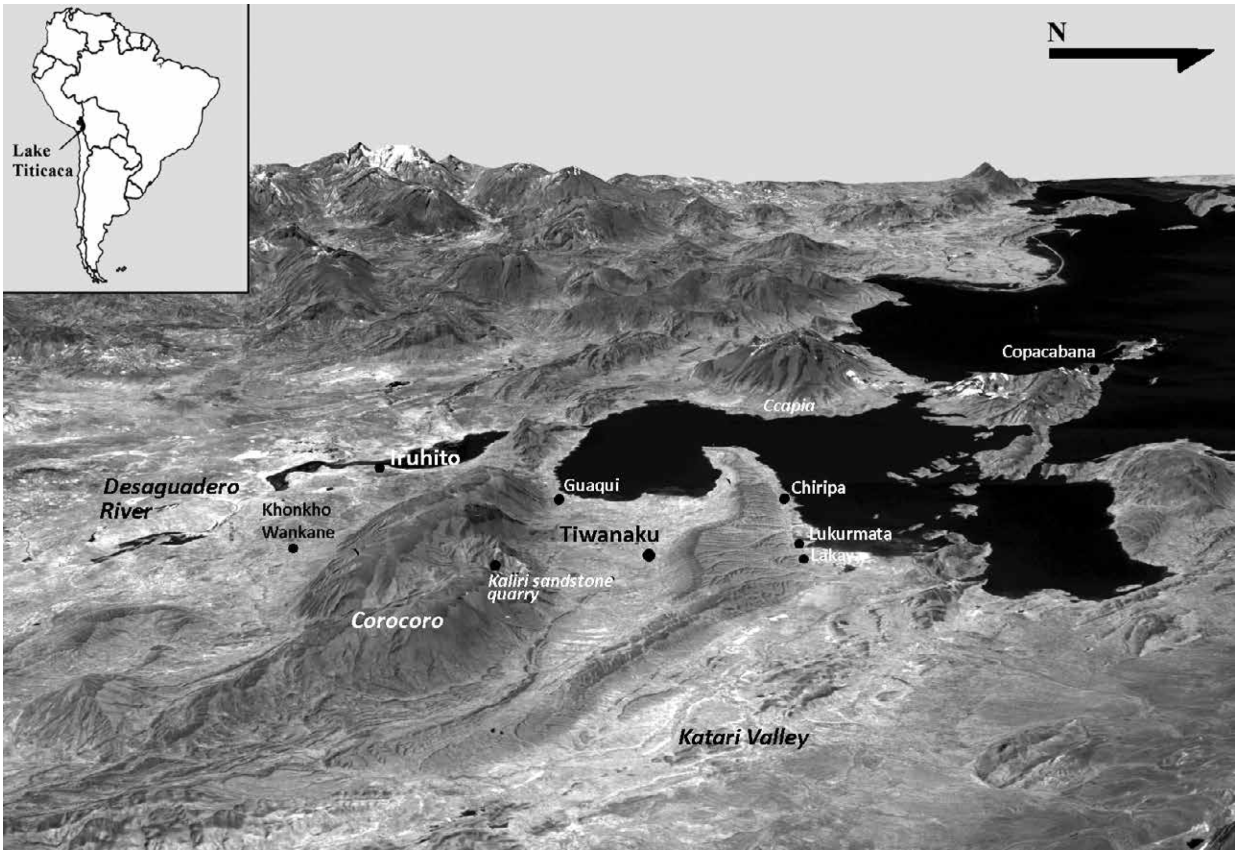

Fig. 15.1 Oblique of the southern Titicaca Basin, based on a composite map by Arik Ohnstad, using Landsat and SRTM topographic data (image Janusek 2020, 95, included with permission from the author's estate).

is central to agricultural production. Agriculture is a reciprocal contract you cannot escape from. One must feed the land, as the earth is the domain of the ancestors and ancestors own the earth and its produce. If one does not feed the land (and the ancestors) then the land won't feed the living. Using the land to farm makes this contract binding (Bolin 2010).

These obligations to nourish can take many forms, conversations, offerings, prayers, rituals, libations, songs and food stuffs, at the places where productive activities take place and at especially powerful locations that radiate out across the landscape (hilltops, springs). These actions are often described as flows of feeding that circle around and return to the person giving the gift, received as support, protection, and a good harvest. Some gifting events are enacted by individuals, alone at a location or to a specific being, whereas other events are more formal, completed in groups for the community. This is often enacted through communal meals among people and beings, as all are supported over time through ingesting, digesting, and expelling (Weismantel 2001, 91). By eating together, all remain strong (Paulson 2006).

15.4 An Andean example

The Andean region has a long arc of domestication, sustainable culture and food production, between the first settlers of the altiplano until today, domestication has been ongoing. Of course, there have been many cultural ruptures and shifts, many conquests and political realignments, but what is quite wonderful about this region is how there have been steady activities that have allowed the residents to continue living in their landscapes and communities. I want to propose that their indigenous worldview has been critical for this long-lived success, where meaning and production are intertwined in an animated landscape that people interact and produce within; *feeding the landscape as the land feeds them*, producing sustainable food within an indigenous ontological approach.

The Andean region of South America is a region of early indigenous plant and animal domestication. The Taraco Archaeological Project has primarily focused on the evidence for longevity and sustainability within this stark landscape of the indigenous Aymara ancestors. This research is located on the Taraco Peninsula, which is a jut of land that extends into the shallow, southern lake, surrounded by the Andean altiplano, a vast, cool high

Fig. 15.2 Harvest cooking at Santa Rosa, Bolivia (Bruno 2008, 206, included with permission from the author).

grassland with marked wet and dry seasons, that over the course of time, witnessed the transition from foragers to complex states. At 3800 m asl the lake basin is unique as a large lake surrounded by steep mountain ranges, with diverse ecological zones dropping off on either side (Fig. 15.1). The Taraco Peninsula is home to one of the renowned Formative period archaeological settlements in the basin, Chiripa. The peninsula's unique linear geography is a spine of hills that slope down to the lake on both sides, cut by thin, alluvial valleys. This landscape provides a set of linear microzones, with the hills for farming and grazing down to the spring filled coastal plain for grazing and food processing and the lake's shallow water for fishing, birding, and gathering. As the climate and lake stabilized in the Holocene, foragers became residents, eventually constructing community buildings and family dwellings as they engaged more intensively with local plants, animals and landscape. This is the ecological setting where potato and quinoa were domesticated, and also llama and alpaca, the two domestic camelid species known for their wool, meat and load carrying, all making this one of the core domestication centers of the world.

The Formative phase of built settlements begins around 2000 BCE in the southern basin, and culminates at the major ceremonial center Tiwanaku. That city began growing in regional influence around CE 400 that lasted for 700 years when the ceremonies halted, the caravans stopped carrying supplies to the center and the population disbursed into small settlements across the altiplano and beyond. The local farmers on the peninsula continued on throughout. We have tracked the core food taxa over time, dominated by local tubers, quinoa, fish and camelids [potatoes (*Solanum tuberosum*), oca (*Oxalis tuberosa*), papa lisa (*Ullucus tuberosus*), quinoa (*Chenopodium quinoa*), fish (*Orestias*, *Trichomycterus*), llama (*Lama glama*), and alpaca (*Vicugna pacos*)] (Bruno 2008; Miller et al 2010, 2021; Moore et al 1999; Whitehead 2007). The organic remains excavated and analyzed portray shifting but steady

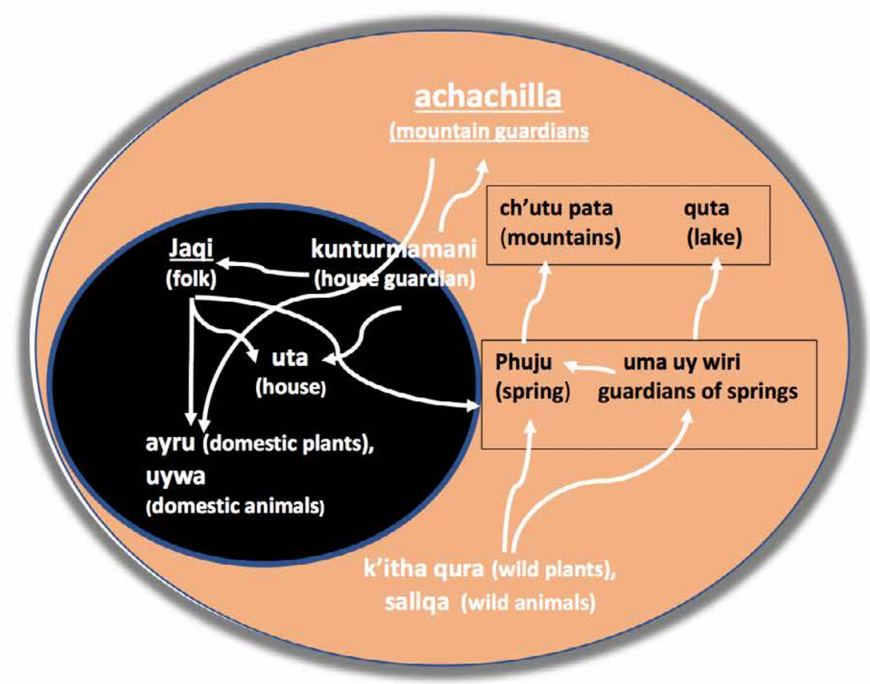

Fig. 15.3 An Andean world view of households, rocks, water, animals, plants and people (C.A. Hastorf and the TAP team 2017, included with permission).

evidence for production of these main taxa throughout the archaeological sequence of settled life. Today, communal harvest meals are shared with the earthbeings, cooked outside in contact with the earth, using clay pots on mud brick oven-hearths, fueled by wood, dung and grass (Fig. 15.2; Orlove 1998). This indigenous food is specifically linked to the earthbeings that provide these food gifts to the attendees, centered around piles of tubers. Offerings are given at the beginning of the meal to the earth and all that helped with the yield, sent by smoke and liquid.

The current residents' ancestors have been through a great deal since the Tiwanaku dissolution, with the Inka conquest, the Spanish conquest and then the equally repressive Republican era, filled with haciendas across the lands, which were dissolved only in the 1950s, whose long-lived structures continue today, with continued racist actions by the non-native population. Through their intimate and constant engagement with the landscape, the residents have been able to produce enough food for themselves. Beings, such as animals, plants, rocks, bodies of water, constellations, and the meteorological elements are not passive backdrops nor abstract spirits; they are tangible beings who people influence through recognition and feeding, who in turn help maintain the people. These interrelationships today are forged through practices of care and gifting of farming harvests.

In 2017 and 2018 we conducted interviews in the community of Chiripa. It is home to a rich archaeological record that represents over 3000 years of settled village life, where farming, herding, and fishing provided the underpinning of economic, social, and political life. Based on their request, the interviews were focused on the residents' personal interactions with their landscape, recording their own ontological concepts of their world. These discussions revolve around agricultural production and maintenance of the landscape and all that dwells on it. As with other ethnographies in the Andes, we recorded reciprocal relationships between people and earth-beings, maintained through rituals that were aimed at assuring successful agricultural productivity. Energy and life force circulate through the landscape, linking the mountains to the lake and all that dwell in between, manifested in the links between main landscape features animals and plants, located throughout the landscape as illustrated in Fig. 15.3.

This diagram illustrates my version of Chiripa residents' ontological relationships with plants and animals, both wild and domesticated, mountains, water, households, and the landscape. There are a series of ways residents gain knowledge to predict and influence meteorological phenomena that in turn help them better tend to their crops and animals, most specifically about the quantity of rainfall, as well as the timing of hail and frost (Mamani-Bernabé 2015). We heard many stories of how wild animals (*salqa*), as messengers between the worlds, communicate with people, especially about the weather and the next rainy season. These are anticipatory interactions where beings inform people. A second important interaction type serves to protect crops and

Fig. 15.4 The Sayhuite stone: Abancay, Peru (©Wikimedia Commons, credit photo to: AgainErick, CC BY-SA 3.0).

animals from potentially harmful meteorological events that are initiated by people. These are completed through rituals that feed the land, water and clouds to sate them, calming them such that they will work with the people towards successful harvests. This is done via offerings of libations and smoke over several processional days encircling the community's farmland. Such "agricultural" propitiations are common, as it is important to keep these wild guardians of water and crops: cats, toads, and birds, contentedly on the landscape, as their presence protects the crops.

Another important form of feeding in Chiripa occurs at home. Every household has a protective being called a *kunturmamani* (grandfather protector of the home) that receives daily interaction in the form of libations and words (Fig. 15.3; Mamani-Bernabé 2015, 72). These offerings are done to keep all within the household protected. Key in their incantations is the verb, *uywiri*, meaning nurturing and guarding. This act of nurturing occurs in two directions, nurturing the people who care for the household protector beings.

One aspect of this ontology that became clear in our interviews was the importance of water, especially the springs, both on the plain and in the hills. These springs have been their source of drinking water as the lake is brackish. Many farming tasks are completed at the springs, watering animals, as well as cleaning, fermenting and leaching crops. These are locations of power that must be cared for. At one hillside spring, Pilani, we learned about how all springs have wild cat guardians. Facundo Llusco, our colleague and a Chiripa resident, told us that if the springs are not cared for and protected, the cat guardians will depart from them and the springs will dry up. These interrelationships are activated by reciprocity, caretaking, and obligation between all of the guardians. The active ingredient is guarding and gifting, watching over each other in a network of connectedness.

Important here is not to directly link the present activities with the past but to seek the common relationships that help illuminate what we think we know about the past and the reality of our constructions about the dynamics of placemaking (Haraway 1988; Ingold 2000; Latour 1993). What evidence do we have for such

Fig 15.5 Lithic carved plaque from Chiripa mound, Middle Formative, National Bolivian Museum of Archaeology, La Paz, Bolivia (photo: CA Hastorf).

animating interrelationships in the past? Fig. 15.4 presents a stone boulder, the Sayhuite stone, that was carved during the time of Inka rule, around CE 1450. It clearly illustrates this animated landscape ontology (Fig. 15.4). This carved image of the animated landscape is filled with cat guardians, water beings, flowing water, and terraced fields, materializing the blended spiritscapes of these earthbeings with the landscape of food production. We see in this example how the guardians are part of crop propagation, animals and people; materializing the web of interconnectedness, potency and fertility. Such a linking argument helps us tack between the present and the past in the Andean region.

Was this ontology operating in the deeper past at Chiripa? Turning to the earlier Formative evidence at Chiripa, Fig. 15.5 is a stone carved plaque from Chiripa's ceremonial platform mound. It reflects a sprouting being, part potato, part toad, the materialization of the earthbeing's life force. Today toads found in fields suggest a good tuber harvest (field notes 2016, Mamani-Bernabé 2015, 6). The animating, sprouting life force emanates out in all directions, encompassing both water beings and terrestrial camelids. All are fed when these beings are honored. Such indigenous viewpoints ask us to resist the practice of translating indigenous knowledge into our own categories, while we see them resonate through time.

15.5 Conclusions

What have we learned about an ontology where society and land are mutually sustained through feeding and caring for each other? Where ensuring the beings one dwells with are well-nourished as well as your own family is, – this is a form of ecological balance, or resilience. Both the current ethnographic evidence of traditional food systems as well as the materialized past farming evidence from this Andean region speak to the resident's engagements with the earth, mountain, sky, water, animal, and plant powers as food and feeding circulate between all. The past stone carvings inform us that the residents saw all things across the land and heavens as an interconnected set of beings that required nurturing, not domination over, in order to be sustainable. Certain places, like springs are not just manifestations of the larger landscape but are also centripetal concentrations of these chthonic, sustaining powers that brought people together in a community to work with the landscape beings.

This Andean ontological example helps us understand how social worlds have been intertwined with landscape as one, outside of the nature/culture divide, placing wild and domestic crops and animals, springs and hail at the center of human society, based on the concept of feeding. By including both modern ethnographic material and archaeological evidence, I have tried to break away from the Cartesian nature-culture dichotomy, to demonstrate how the landscape beings participate in cultural sustainability through recognizing and gifting. These concepts resonate in the Formative evidence as it does in today's community rituals and beliefs, despite a series of conquests, climatic and lake-level shifts over the millennia, reflecting the sustainability of these Andean ontological visions of their world.

Clearly, this indigenous ontological model is not the only sustainable strategy that has worked in the past, but for the Americas, versions of this web of intimate watching, caring, feeding, and sustaining has been successful in many places and times. Such indigenous ontologies provide models for how people can sustain both their land and their community today, a variant of TREM, suggesting some ideas that we might consider not only in our archaeological interpretations but in our own society. Their basic concept is that everything must be fed, let nothing go hungry. For we too love to receive gifts of food from those we love as well as give food to those we love.

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Chapter 16

Grinding and pounding in Early Neolithic southeastern Europe: culinary preferences and social dimensions of plantfood processing

Ismini Ninou, Nikos Efstratiou,
Soultana-Maria Valamoti

Abstract

The use of grinding stone tools for the processing of various materials constitutes an essential technological practice, documented since Paleolithic times; though the intrinsic connection between food processing stone equipment and the beginning of agriculture has been loosen, it is evident that their quantity and variety increased towards the onset of the Neolithic. In the transition from hunting-gathering to food production, food processing stone tools may acquire characteristics that serve the new demands and therefore indicate new cultural choices connected to subsistence. The technomorphological features and the patterns of use of food processing stone tools in the early stages of agricultural economies could reveal aspects of daily food habits and adaptations in the new subsistence models. Using the grinding and pounding stone tools assemblage from the Early Neolithic site of Mavropigi-Fillotsairi in Western Macedonia, Greece as a case study, this paper examines the data that concern variation in the use of food processing stone tools of the early agricultural societies of Southeastern (SE) Europe. The particular assemblage from Mavropigi-Fillotsairi with the almost exclusive presence of passive pounding tools/mortars raised a problematic towards the variation of food processing techniques in Early Neolithic in the area. This dataset is examined in the context of published Early Neolithic food processing stone tools from Greece and the Balkans in order to understand some aspects of the technological and economical choices, the food production and identity of early Neolithic societies.

Keywords: *Early Neolithic Greece and Balkans, grinding and pounding tools, plantfood processing*

16.1 Introduction

Plantfoods have constituted essential food elements for hunter-gatherer and perhaps even more so for farming communities. Plantfood processing with stone tools, namely grinding and pounding tools, enable higher accessibility to food nutrients, especially plant foods essential to farming communities (like grains, nuts or herbs) (Butterworth et al 2016; Stahl 1989). Best energy extraction from grains is accomplished via smashing

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and pulverizing and consequently, the same amount of food feeds more people (Ivanova 2018). Moreover, the transformation of raw ingredients via grinding and pounding renders cooking more versatile and complex and generates a wide range of ingredients that could be used in culinary practices, something that is indicated by archaeobotanical finds of plant food processing from prehistoric SE Europe (cf Valamoti et al 2019). Cooking is all about combining materials, smells and flavors; grinding and pounding processes help food ingredients to be mixed more thoroughly, allowing for more complex preparations (requiring for example lactic acid or alcoholic fermentation) thus leading to a greater variety of recipes and resulting food preparations and dishes (see also Fuller and Rowlands 2011). Through this process, grinding and pounding tools mediate between human culture and natural environment by transforming plants into food ingredients and cooked meals. In this manner, food processing stone toolkits allow insights of this complex interaction of resources, environmental conditions, cultural traditions and change in space and time.

Grinding and pounding stone tools are found sparsely at Paleolithic sites, usually in small numbers (Araguren et al 2007; Goren-Ingbar et al 2002; Kraybill 1977; Piperno et al 2004; Shea 2013; Wright 1991). Direct evidence that could associate them to plantfood processing is rare (Wright 1991), but recent analyses (phytoliths, starch grains) suggest that grinding foodstuffs possibly had been practiced to some extent at that time (Araguren et al 2007; Cristiani et al 2016; Jones 2009; Lippi et al 2015; Power 2009). Grinding and pounding become more systematic before the advent of the Neolithic, as they are documented by relevant equipment from pre-agricultural settlements in Near and Middle East (Kraybill 1977; Wright 1991). The number of tools significantly increases and there is notable variation on tool types, raw materials, tool morphology and manufacture techniques. Their use is broadened and it can be securely linked to plantfood processing. However, it is evident that with the transition to Neolithic, archaeological sites increase in number while there is evidence for technological modifications brought along with the new way of life including experimentation and innovation in food processing stone tools (Dietrich et al 2019; Dubreuil 2008; Dubreuil and Nadel 2015; Runnels 1981; Wright 1991, 1992, 2000).

In contrast to the rich data from Southwest Asia, we know little about grinding and pounding tools and related cooking methods of the first stages of Neolithic economy from SE Europe. Evidence of plantfood processing with stone tools from periods preceding the onset of the Neolithic in Greece and the Balkans are extremely rare (Antonović 2003b; Runnels 1981, 100; Sampson 2008, 162; Sampson et al 2002; Stroulia 2010, 15-26). Most of these artefacts are active grinding tools/grinders which cannot be associated unequivocally with plantfood processing or any systematic grinding activity. Likewise, there is very little information and analysis on food processing stone tools from Early Neolithic sites of the area (Bekiaris et al 2020).

The interpretive dynamics of food processing stone tools for farming communities of SE Europe have been highlighted in the relevant literature in multiple ways (for further references see Bekiaris et al 2020; Ivanova 2018). In this paper, we wish to contribute to the research on food processing equipment and methods during the first phases of the Neolithic in SE Europe. The interest was sparked by the particular characteristics of food processing stone tools from the Early Neolithic site of Mavropigi-Fillotsairi in Western Greek Macedonia. Based on the features of this assemblage, a problematic is raised as regards the food processing techniques and habits in the new lifeways introduced in the Early Neolithic and the appearance of farming societies in our study region.

16.2 Materials and methods

The present research attempts to approach two questions related to food preparation among the first farming societies of SE Europe. The first concerns the investigation of grinding and pounding processes, their possible complementarity and/or preference of one over the other. Pounding and grinding activities are linked to specific plantfood processing (Dubreuil 2008), so the presence or absence of each type of tool may imply different processing and/or cooking methods. The second question concerns the context in which stone tools were used for food processing in Early Neolithic sites of our study area. Since "food processing and ground stone tools are key to identifying the domestic from the non-domestic" (Wright 2014, 7), the positioning and function of grinding or pounding equipment in a settlement may be related to hypotheses towards distinctions between communal uses of space and individual production units/households. This aspect is particularly significant in the framework of the initial steps of household formation processes and social organisation in the Early Neolithic of SE Europe.

Our research focused on Early Neolithic Greek and Balkan sites, combining a literature review as well as an original case study from northern Greece. We recorded all types of grinding and pounding tools and their contexts on the basis of published site reports and specialist studies (see also Bekiaris et al 2020). The data considered here originate from sites dated between 7000-6000/5900 BC in Greece, while for the Balkans this time frame extends to until approximately 5500-5200 BC considering the complex chronological schemes that are used for Balkan prehistory (see Bailey 2000, 13; Whittle 1996, 37-71).

In the attempt to approach grinding and pounding stone tools of Early Neolithic of SE Europe, it was essential

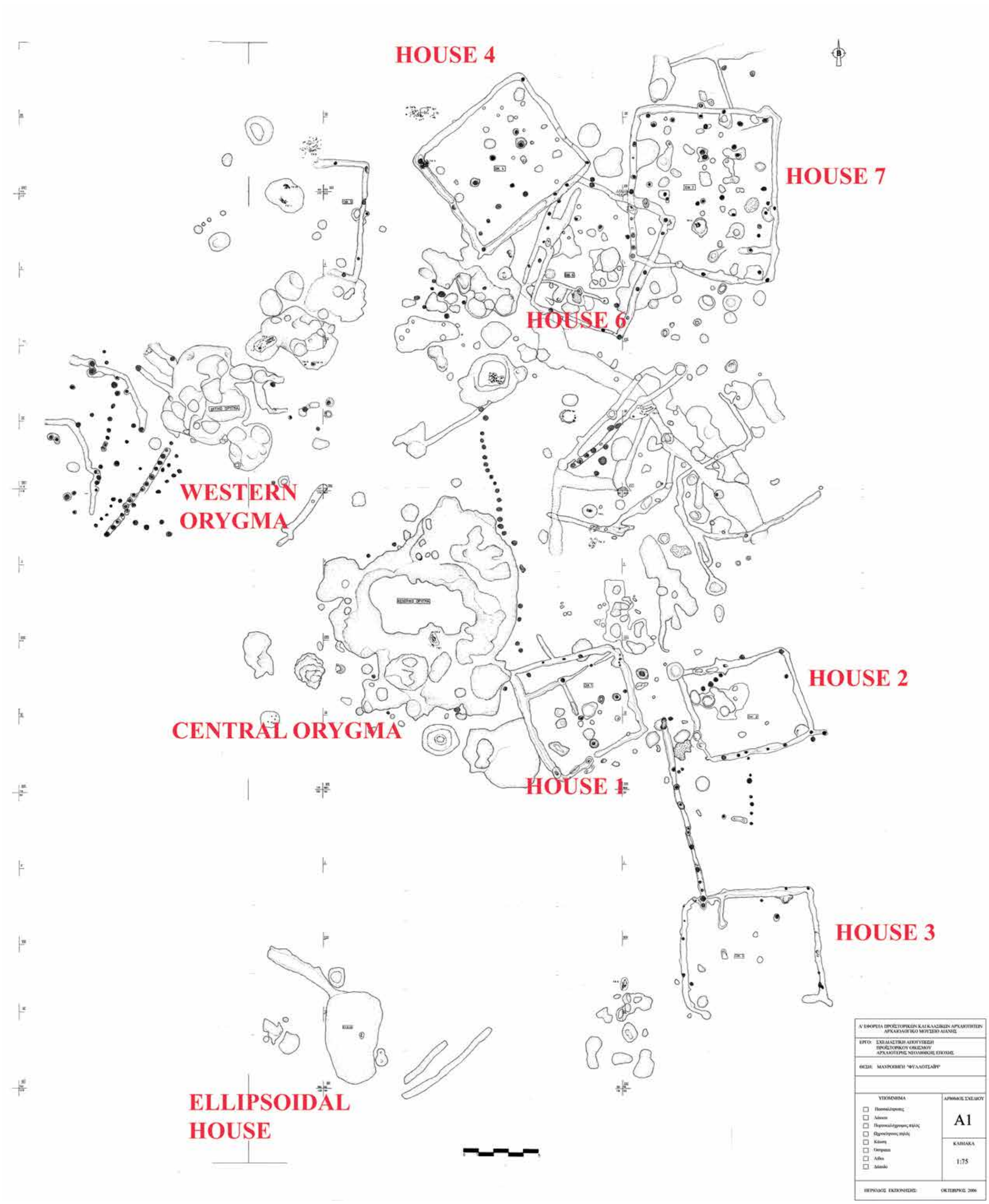

Fig. 16.1 Plan of the site Mavropigi-Fillotsairi (photo: courtesy of Ephorate of Antiquities of Kozani and G. Karamitrou-Mentessidi).

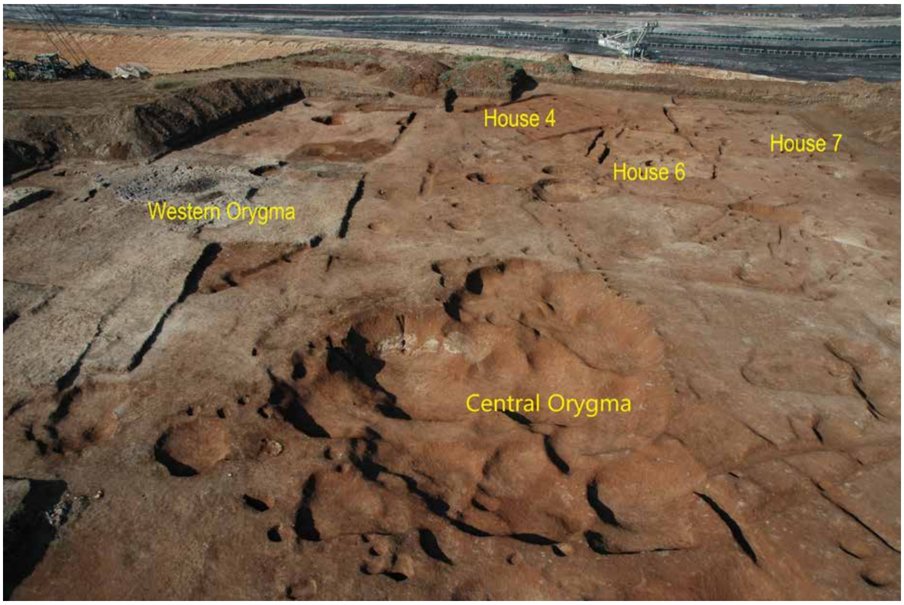

Fig. 16.2 General view of Early Neolithic Mavropigi-Fillotsairi (photo: courtesy of Ephorate of Antiquities of Kozani and G. Karamitrou-Mentessidi).

to consider issues of definition and identification of food processing stone toolkits. This paper is focused on pairs of stone tools that were used for processing plant foodstuffs in prehistory, usually described as grinding slabs and grinders, mortars and pestles. The inconsistencies of types, terms and categorizations of grinding and pounding stone tools have already been presented analytically elsewhere (see Bekiaris et al 2020). Research into grinding stone tools from Early Neolithic and Balkan sites has attempted to distinguish food processing tools from those used for other activities (e.g. tool production or hide processing). This distinction is based rarely on use-wear analysis, relying mainly on the size of tools (smaller grinding tools –often labelled as grindstones– are considered not appropriate for food processing and they are distinguished from the larger ones -usually named querns, which are thought to be used for food processing and cereal grinding in particular (Antonović 2003a, 2003b, 2006; Runnels 1981).

Moreover, grinding and pounding stone tools may have not been identified as tools at all. For example, at Lepenski Vir in Serbia some of the stone altars may have functioned as mortars (Antonović 2006) while at Sossandra, in northern Greece, stone implements with cavities are characterized as stone vessels (Georgiadou 2015). The distinction between a mortar and a stone vessel should rely on specific morphological characteristics (form of the rim, form of the base, treatment of the external surface, use-wear, see Wright 1992), but very often the categorization is decided only on a coarse level by the mere presence of a cavity. Therefore, the characterization of stone mortars as stone vessels or *vice versa* is common (see also Stroulia 2020). A similar issue occurs with the identification of mortars as pivot stones (e.g. Sossandra: Georgiadou 2015; Elateia: Weinberg 1962). In this case, apart from the presence or absence of use-wear, archeological context should be taken into consideration, as pivot stones are associated with certain architectural features that are linked to the presence of posts or openings/doors.

Another parameter that needs to be taken into account concerns the fact that many of the publications are old; many excavations are often restricted to a few trial trenches and the grinding and pounding toolkits are rarely published in detail. Unmodified stones may have been used as grinders or pestles and they might not have been recognized or collected during the excavation. Furthermore, it must be underlined that the research presented in this paper is focused on food processing tools made of stone. The potential use of food processing tools made of perishable materials (such as wood) is often suspected and sometimes is implied, but unfortunately it cannot be archaeologically proved (Adams 2002, 102).

16.3 Grinding and pounding tools from Mavropigi-Fillotsairi

The site of Mavropigi-Fillotsairi is located in the area of Kozani, in Western Greek Macedonia. The extensive rescue excavation revealed an Early Neolithic settlement with three major habitation phases (Fig. 16.1-2). The main architectural feature is a large, oval pit (Central Orygma) which was the first dwelling that was founded at the site and remained in use throughout the whole duration of occupation at site (Karamitrou-Mentessidi 2005; Karamitrou-Mentessidi et al 2013, 2015). In the earlier phases (I and II), the Central Orygma was a semi-subterranean structure, arranged in two spaces/rooms with clay floors, a round hearth and a main entrance. Two other constructions, the Ellipsoidal House (in the south west of the site) and the Western Orygma with successive

Fig. 16.3 Pounding tool/ mortar found in the interior of the Ellipsoidal House (photo: courtesy of Ephorate of Antiquities of Kozani and G. Karamitrou-Mentessidi).

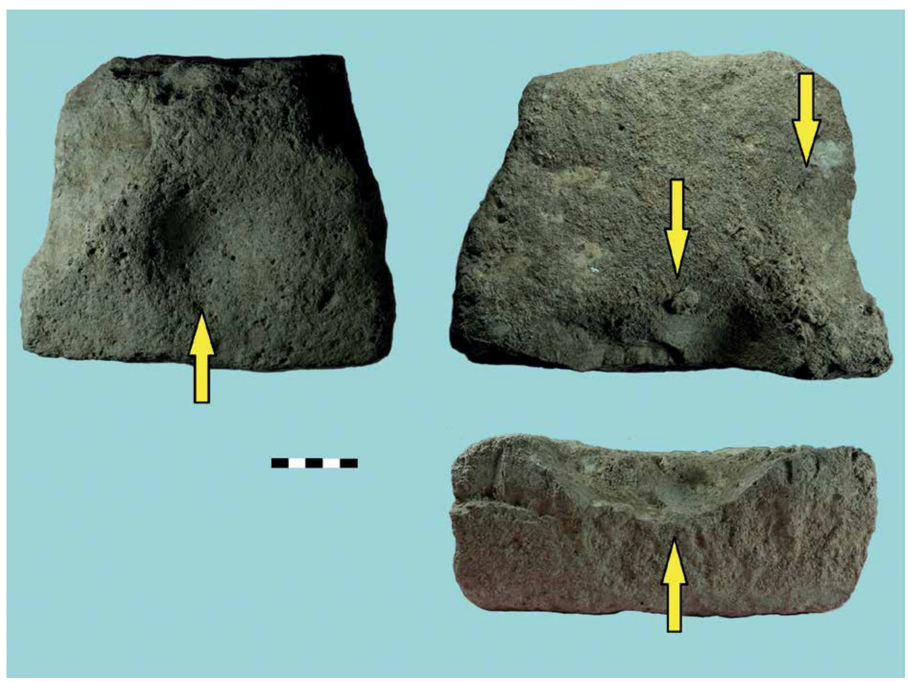

Fig. 16.4 Pounding tool/ mortar with different redesigning episodes (three cavities on different workfaces) from Mavropigi-Fillotsairi, phase III (photo: I. Ninou).

habitation floors have been dated to phase II. In phase III that follows, the Central Orygma was replaced by a larger ground level structure with a more complex plan. In this phase, 7 rectangular building/houses were recovered to the north and east area of the Central Orygma, constructed on ground level with wooden posts and clay floors. Numerous pits and ditches have been excavated in the space between them, along with 18 burials.

The dominant type of food processing stone tool at Mavropigi-Fillotsairi is the mortar/passive stone tool with cavity (see Table 16.1 and Fig. 16.3-4). The tools are mostly limestone and gneiss boulders with sides roughly shaped with battering, flaking and pecking. Their length varies from 20 to 42 cm. The cavities usually are shallow (av. max. depth 5.8 cm.) and wide (av. diameter 10.06 cm). What is also interesting is the high rate of tool reuse and redesign (Fig. 16.4); most of them carry more than one cavity, on the same or opposite surfaces, or were broken and new cavities had been shaped. Examination of use-wear suggested that the tools functioned with a combination of grinding and pounding actions of varied intensity, possibly with wooden pestles (Chondrou et al this volume).

Fig. 16.5 Example of active pounding tool/pestle (photo: I. Ninou).

Regarding active pounding tools, only ten stone pestles have been identified in the overall ground stone assemblage, all belonging to phase III. Their length varies from 6.95 to 14.49 cm. They are made of volcanic rocks (diabase, gabbro, granite) or sandstone pebbles, often lightly ground or pecked in order to fit in the hand. The use-wear traces that are observed are mostly levelling and scratches, suggesting the application of light force with vertical and horizontal movements while in operation (Fig. 16.5).

Some differentiation in the tool types and their distribution has been observed in the three phases of the settlement. In phase I, no food processing stone tools in terms of grinding or pounding were found in the overall ground stone tool assemblage. In phase II, mortars were found in the Ellipsoidal House and in the Western Orygma, but no grinding tools were identified. Based on the excavation data, it is quite secure to assume that the mortars were found *in situ*. In phase III, when the settlement expands, tools with cavities continue to be present, usually in a very fragmentary state. An intact tool with cavity was located in a pit inside House 1, while in the Central Orygma a large grinding tool (26 cm length) was found on one of the later floor layers (Fig. 16.6). This is the only safely identified grinding tool of the site and it was located packed in the floor of the house with the work face placed upwards. It is characterized as a grinder based on observations on the morphology of the workface and micro use-wear traces (Chondrou et al this volume), while its position indicates its use as a grinding slab. Maybe, it is safer to consider this tool as a grinder reused as a grinding slab.

Therefore, in the initial phase of Mavropigi-Fillotsairi (Phase I), no food processing stone tools were identified. This may be related to the limited extent of the settlement and the overall scarcity of archaeological finds during this phase (Bonga 2015, 2020; Karamitrou-Mentessidi et al 2015; Michalopoulou 2017).

In Phase II, by contrast, stone mortars are located inside the Western Orygma and inside the Ellipsoidal house. The former has been interpreted as a pit house/dwelling by the excavators (Karamitrou-Mentessidi et al 2015). The association of the mortar to hearths can support the hypothesis that food preparation might have taken place inside the Western Orygma; the hypothesis that mortars can be transferred elsewhere cannot be excluded, though the specific tools are rather bulky and heavy. In Ellipsoidal House, a mortar was found in its interior, fixed on the floor, without any indication for other cooking activity (such as hearths) (Karamitrou-Mentessidi et al 2015). Inside the Central Orygma (which is considered the core of the settlement Karamitrou-Mentessidi et al 2015; Kotsakis 2018), no food processing stone tool was located in phase II while other indications for food preparation have been identified (e.g. hearths).

Fig. 16.6 The only securely identified grinding tool from Mavropigi-Fillotsairi on the floor of Central Orygma (Phase III) (photo: courtesy of Ephorate of Antiquities of Kozani and G. Karamitrou-Mentessidi).

In the successive phase (Phase III), a stone mortar was found, probably *in situ* inside rectangular House I. In Central Orygma (Phase III) the only grinding tool that was previously described was found on the floor.

Irrespective of the suggested function of buildings and pit houses at Mavropigi-Fillotsairi, it is interesting to notice that the mortars are found inside sheltered spaces while pounding (especially pounding for dehusking) is generally considered an open air activity (Ertuğ-Yaras 2002; Tsartsidou and Kotsakis 2020). Nevertheless, there is no reason to exclude pounding being performed in sheltered spaces. Mortars could have been moved (possibly with difficulty because of their size) in different parts of the settlement, including open-air spaces.

It must be underlined that the excavation process included the collection of all lithic material from the archaeological deposits and after the examination of all bulk material, no other food processing grinding tool was identified, not even in fragments. Therefore, this assemblage, characterized by mortars and pounders emerges as an exception for Neolithic Greece, considering the rarity of pounding equipment from this period (Bekiaris et al 2020).

16.4 Grinding vs pounding in Early Neolithic Greece and the Balkans.

In order to further understand the particularities of the assemblage from Mavropigi-Fillotsairi, a survey of published evidence for grinding and pounding tools from Early Neolithic sites of SE Europe was conducted (see Table 16.1). The majority of Early Neolithic sites have yielded grinding tools, while fewer have pounding equipment (see Fig. 16.7 and Fig. 16.8). There are cases where grinding tools are present and no pounding tools (mortars or pestles) have been reported, as in the Early Neolithic layers of Sesklo (Wijnen 1981, 41-43), Argissa (Hanschmann and Milojcić 1962), Lerna (Runnels 1981), Prodromos (Moudrea 1975), Revenia (Besios and Adaktylou 2006), Slatina-Sofia (Nikolov 1989) and Anza (Weide 1976). At other sites such as Achilleio (Winn and

SITE	TOOL TYPE				DATE*	REFERENCE
	Tools with cavity/ passive pounding tools	Pestles/active pounding tools	Grinding slabs/ passive grinding tools	Grinders/active grinding tools		
Achilleion	0	X	90	±100	6380-5700	Winn and Shimabuku 1989
Anza	0	NS	52	NS	6510-5200	Weide 1976
Argissa	0	0	X	X	6660-6460	Hanschmann and Milojcić 1962
Ayios Vlasis	X	X	X	X	Early Neolithic	Chondrou pers.observ.
Blagotin	0	0	0	0	6430-6020	Greenfield and Jogsma 2014
Divostin	0	0	X	0	6200-4590	Galdikas 1988, 338-341
Donja Branjevina	0	3	5	0	6030-5700	Antonović 2002
Drosia	0	0	X	X	Early Neolithic	Kotsos 1992
Elateia	X	X	X	X	Early Neolithic	Weinberg 1962
Foeni Salas	1	0	0	0	5900-5100	Greenified and Drasovean 1994
Franchthi	2	0	4	0	6640-6210	Stroulia 2010
Karanovo	>1	NS	5	NS	Phases I-II 6000-5750, 5730-5500	Höglinger, P. 1997
Kazanlak	37	150	770	42	6000-4000	Kanchev 1981
Knossos	4<	NS	10<	0	7030-6780	Evans 1964; Efstratiou el al 2013
Lepenski Vir	1	X	2	X	6350-4700	Srejović 1972; Srejović and Babović 1981; Antonović 2006
Lerna	0	0	<13		Early Neolithic	Runnels 1981
Mavropigi-Fillotsairi	7	10	0	1	6600-5900	Ninou in prep
Mirki Volvi	0	0	X	X	Early Neolithic	Lioutas and Kotsos 2006
Nea Nikomedeia	0	10	22	14	6500-6000	Pyke 1993
Padina	0	X	X	0	6650-5600	Antonović 2008
Paliambela	X	NS	NS	NS	6600-6000	Kotsakis 2018; Tsartsidou and Kotsakis 2020
Prodromos	0	0	X	X	Early Neolithic	Moudrea 1975
Revenia	0	0	X	X	Early Neolithic	Besios and Adaktylou 2006
Servia-Varitimides	1	13	2	0	5890-5670	Ridley et al 2000
Sesklo	0	3	9	21	6590-5890	Wijnen 1981, 41-43
Slatina	0	0	X	X	5810-5750	Nikolov 1989; Nikolov and Takorova 2018
Sosandra	3	0	19	6	6066-5840	Georgiadou 2015
Velesnica	0	X	X	0	6200-5900	Antonović 2003b
Yabalkovo	X	X	X	X	5998-5846	Leshtakov et al 2007; Leshtakov 2014
Yiannitsa B	0	0	X	X	Early Neolithic	Chrysostomou 1989
Index	**0** Not present	**X** Present/not exact quantity available	**NS** Not Specified	**<** more than (when author mentions exact numbers but doesn't distinguish tool types)		

* Apart from the dates that every publication may refer to, for the synthesis of the table we have consulted the following references: Reingruber and Thiessen 2015; Bonsall et al 2015; Whittle 1996; Bailey 2000; Maniatis et al; Kotsos 2018.

Table 16.1 Frequency of food processing stone tools types in Early Neolithic sites of Greece and the Balkans.

Shimabuku 1989), Nea Nikomedeia (Pyke 1993) or Donja Brajevina (Antonović 2002), grinding toolkits are found, as well as pounding active tools/pestles but no corresponding mortars. Both types of pounding and grinding tools, active and passive, are reported from Yabalkovo (Leshtakov et al 2007; Leshtakov 2014), Lepenski Vir (Srejović 1972; Srejović and Babović 1981; Antonović 2006), Karanovo (Höglinger 1997) or Kazanlak (Kăncev 1981). Furthermore, pounding has been practiced during the Early Neolithic at Paliambela in specifically designed pits/bedrock mortars (Kotsakis 2018; Tsartsidou and Kotsakis 2020). At Foeni-Salaş, in SE Romania, a single stone mortar was located without any other grinding or pounding stone equipment (Greenfield and Draşovean 1994), while at Blagotin no food processing stone tools were found at least at the earliest phases (Greenfield and Jogsma 2014; Jesik 1998; see also Ivanova 2018). At Franchthi cave, both grinding tools and tools with cavities have been recorded but they have been interpreted as having functions other than food processing; the quality of raw materials and the morphology of the cavities support the hypothesis this type of tool was used probably for processing other stuff (such as clay) or as container rather than cereal processing (Stroulia 2010, 56).

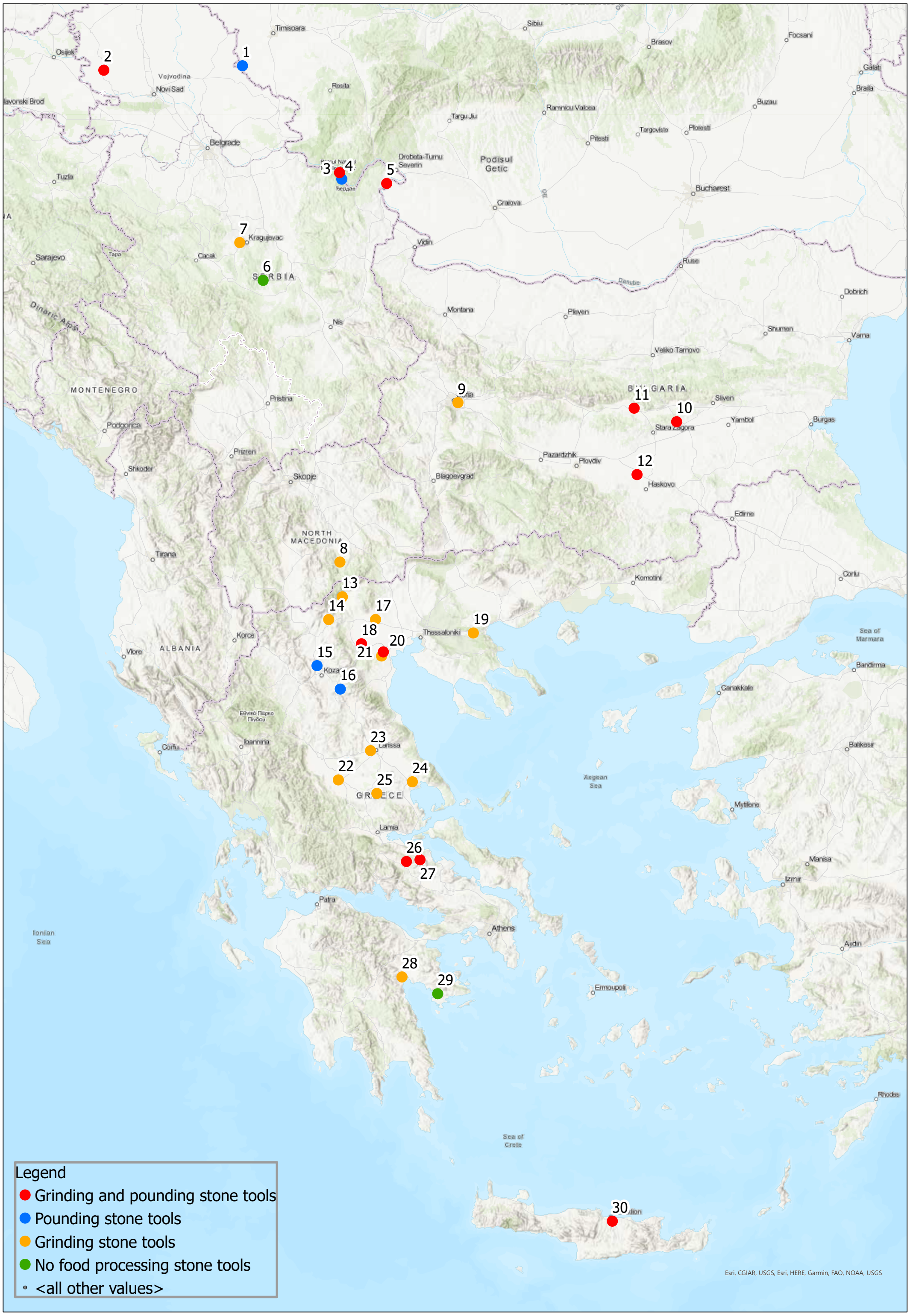

Fig. 16.7 Map of Early Neolithic sites in Greece and the Balkans picturing variation in food processing equipment 1.Foeni Salas, 2.Donja Branjevina, 3.Padina, 4.Lepenski Vir, 5.Velesnica, 6.Blagotin, 7.Divostin, 8.Anza, 9.Slatina Sofia, 10.Karanovo, 11.Kazanlak, 12.Yabalkovo, 13.Sosandra, 14. Drosia, 15.Mavropigi-Fillotsairi, 16.Servia-Varitimides, 17.Yiannitsa B, 18.Nea Nikomedeia, 19.Mikri Volvi, 20.Paliambela, 21.Revenia, 22.Prodromos, 23.Argissa, 24.Sesklo, 25.Achilleio, 26.Elateia, 27. Ayios Vlasis, 28.Lerna, 29.Franchthi cave, 30.Knossos (map designed by T. Roustanis and P. Tokmakides).

Variability in food processing tools and techniques is enriched by other archaeological evidence from the Balkans. For example, at Foeni Salaş, it is assumed that grinding may have been performed with the use of ceramic plates (Greenfield and Drasovean 1994). At sites where pestles are found without any stone mortars, such as Velesnica (Antonović 2003b) or Donja Brajevina (Antonović 2002) the use of mortars made of wood has been hypothesized. It is important to underline here that pestles occasionally function without stone mortars. The processed materials are contained in dug-out cavities formed directly on bedrock or other concave recipients, such as pits (Tsartsidou and Kotsakis 2020; Tsoraki 2008; Valamoti 2009, 56). Conversely, when stone mortars are found in the absence of pestles, wooden pounding active tools can be hypothesized as being in use. This suggestion is supported by ethnographic studies that show the extensive use of wooden pestles (Ertuğ-Yaras 2002; d' Andrea and Haile 2002; Hamon and le Gall 2013).

Concerning the ratio of grinding and pounding toolkits –wherever both practices are documented and exact quantitative data are published– grinding tools usually outnumber pounding tools; in this respect Mavropigi-Fillotsairi is a unique exception as the reverse is observed. Additionally, at Lepenski Vir, pounding may have been practiced rather than grinding, if mortars have been misleadingly identified as altars (Antonović 2006). It is important to observe that grinding toolkits are numerous, while pounding tools –whenever they are present– occur in small numbers, maybe one or two in the whole settlement at all the sites we have examined (see Table 16.1).

Information on the context of Early Neolithic grinding and pounding tools in the study area is sparse, but still particularly informative. Grinding and pounding equipment is found in domestic units and/or open areas. Food processing with stone tools is often associated with specific architectural units often in relation to thermal structures and cooking pots, picturing a composite cooking area (see Bekiaris et al 2020, also Bekiaris et al this volume, Chapter 18). This pattern is observed already since the the Early Neolithic, especially in well defined, domestic spaces (e.g. Karanovo: Höglinger 1997, Slatina Sofia: Nikolov 1989, Yabalkovo: Leshtakov et al 2007). The interior of a three-roomed dwelling in Sossandra was equipped with 25 grinding tools, often placed in association with hearths (Georgiadou 2015). Open air food processing areas with grinding tools have been identified at Achilleio, perhaps for collective food preparation (Gimbutas et al 1989). At Lepenski Vir (Srejović 1972; Srejović and Babović 1981), pounding tools (often interpreted as "altars") are found in the vicinity of graves. At Foeni Salaş, the only food processing stone tool of the settlement (a stone mortar) is associated with a pit house (Greenfield and Draşovean 1994). The available data on grinding and pounding equipment in food processing areas in Early Neolithic SE Europe could lend further support to the observation that the spatial organization and material culture of early farming settlements imply a long-term and dynamic interaction (or tension-Halstead 1999, 2012) between open and sheltered spaces, or even collective and domestic entities.

16.5 Grinding and pounding: complementary or mutually exclusive?

Grinding and pounding involve different processing techniques as their differences lie on the modes of application of force and pressure. Pounding, in other words the application of a strong, instant, repeated, vertical pressure on a substance between two tools (a lower, static mortar and an active, dynamic moving pestle, Adams 2002) is performed in order to extract juice from fruits, to de-shell nuts, to pulverize herbs, to clean the husks of cereals, to remove bran from cereal kernels, to smash coarsely the grains before fine grinding or cooking or to smash non edible materials (David 1998). Sometimes, the combination of vertical (pounding) and horizontal (grinding) movements is applied with the pestle in the cavity of the mortar (De Beaune 2004; Leroi-Gourhan 1971). In the case of grinding, the application of pressure (with rotary or to-and-fro motion) on a substance between two stone tools (a passive, stable grinding slab and an active, moving grinder) is more uniform and results into a finer product[1]. The two categories of tools can be used for the processing of the same substance but in a different manner, with different purpose or in a different phase of processing (Ertuğ-Yaras 2002; Lundstrom-Baudais et al 2002; Robitaille 2016). For example, to produce bulgur, a pounding tool is necessary for debranning, but grinding slabs are used for grinding it coarsely (cf Valamoti 2011b).

In order to approach variation in food processing techniques, we must look first to the desired foodstuffs that might have been, derived from different crops. Grinding is a process that usually aims towards the production of finely and more or less uniform ground products. For example, regarding cereals, differences in the degree of grain grinding allows different cooking recipes (Valamoti 2011b, Valamoti et al 2021). Finely ground cereal or products (flour) are versatile as the grains can be exploited more efficiently by the human digestive system (Ivanova 2018; Stahl 1989); the production of flour requires a significant amount of time (depending on multiple factors such as the size and material of the grinding tools, the age, sex and experience of the grinder, Adams 1989; Nixon-Darcus 2014; Valamoti

1 The production of barley flour with the use of mortars has been tested experimentally (Eitam et al 2015), so the use of mortars for finer products should not be completely excluded.

et al 2013), but cooking time is significantly reduced (Ivanova 2018). Fine grinding of grains, not just cereals, significantly broadens the range of foodstuffs that can be produced: cakes, pancakes, breads, biscuits, rusks, pies, soups etc, increasing significantly the range of potential cooking recipes. Meals prepared with finely ground seeds and grains may be baked in ovens, hearths, directly on embers or on ceramic or stone plates (Bekiaris 2018, 303) or boiled in pots (Dimoula et al 2020).

By contrast, pounding (applied either as a processing step for removing undesired parts of grains, prior to grinding, or as a single food preparation process) usually results in coarser end-products. They could be used for the preparation of groat meals and the best cooking method for them is boiling in a pot. For the processing of substances other than cereals, such as oily seeds, nuts, fruits rich in juice, pounding maybe be a more efficient method, because it allows the use of all parts of the substance, solid and liquid, as the concave interior surface of the mortar confines the processed material thus preventing its dispersal and loss (Ertuğ-Yaras 2002). Additionally, pounding tools are used for mixing edible substances, in a technique involving simultaneous mixing and smashing (usually herbs, nuts and fruit), resulting in a combination of uncooked meals, like sauces or pastes (Hamon and LeGall 2013).

Wooden pounding tools have been reported ethnographically (Hamon and Le Gall 2013; Schroth 1996; Wright 1994) and their efficiency has been verified experimentally (Meurers-Balke and Lüning 1999). Their use in archaeological contexts is a matter of speculation as they usually do not survive, yet it could account for the absence of mortars and pestles (see Bekiaris el al 2020). Choosing wood over stone for the making of mortars or pestles might be a result of the availability of proper stone raw materials, but it can also be explained because of different preferences in processing techniques. The use of wooden tools is favored when the excessive smashing of the food substance is not desired in the different stages of processing, so that the valuable parts intended for use are not prematurely wasted (Kraybill 1977, 492; Moritz 1958, 25).

In sum, various types of food processing tools are chosen either for the processing of diverse types of foodstuffs or for the different treatment of substances, for the creation of different recipes or as a part of specific cooking techniques. This observation forms the main axis in our investigation of food processing and cooking habits of early farmers in the area studied in this paper.

Differences and variation in foods processing stone equipment have been ascertained in other parts of the world, especially in pre-agricultural and early agricultural phases.

In the Near East, where the assemblages of food processing stone tools are richer and more thoroughly studied, it is ascertained that in early pre-agricultural phases (Kebaran and Natufian) pounding toolkits dominate over grinding ones, while gradually in the following phases, grinding equipment is preferred over pounding tools (Wright 1991). Moreover, a significant shift in the dietary habits from gruel meals of Early Natufian to barley bread in Late Natufian is suggested (Terradas et al 2013); this is explained because bread is a good source of carbohydrates and other nutrients which is easily digested and can also be carried as provisions (Dubreuil 2004; Eitam et al 2015). Various views have been expressed in an attempt to explain the differences in the proportion of pounding and grinding tools with the emergence of agricultural communities in the Near East. In some instances, the dominance of grinding tools is attributed to a modification of the processing techniques (Wright 1992, 1994). Additionally, some scholars correlate the use of grinding tools with household activities, while mortars are associated with communal practices on the basis of their size and position (between the dwellings or in areas around the settlements); thus a shift from pounding to grinding has been associated with the development of household economies at the expense of communally performed food preparation (Belfer-Cohen and Hovers 2005, 304). It has been suggested that the increase in grinding tools maybe due to changes in tool production and social organization of the grinding tasks. The economic and social organisation based on household units implies that tool production and use is oriented towards the fulfillment of separate household needs, having as a consequence the increase of smaller size grinding tools, distributed in domestic spaces (Dubreuil 2008; Wright 2014).

The exploration of the available published data from Early Neolithic Greece and the Balkans shows that various combinations in the use of stone tools for grinding and pounding are documented: exclusive use of grinding tools, combination of pounding and grinding stone tools, preference in pounding and even the lack of use of stone tools for food processing (see Fig.16.8). Based on our observations, although the preference in grinding equipment appears to be dominant, it is not exclusive or uniform.

Grinding tools occur at almost all Neolithic sites of the study area, while pounding tools are notably few in the whole span of the Neolithic, at least in Greece (Bekiaris et al 2020). This uneven occurrence of pounding tools may have been related to practical aspects of food processing: mortars or pestles could have been made of perishable materials. Additionally, pounding as well as some early steps of food processing may have been practiced outside the settlement boundaries, and therefore not traceable through excavation. Stone mortars may not have been chosen because their manufacture is

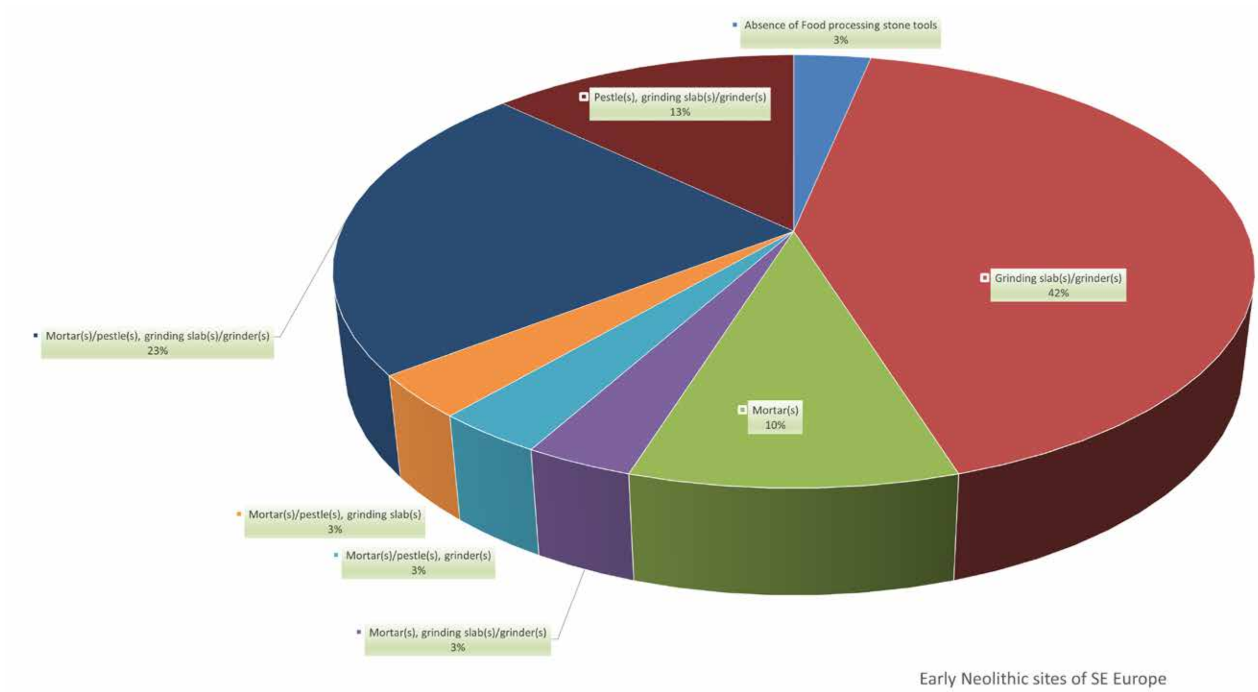

Fig. 16.8 Pie chart showing the frequencies of various combinations of food processing stone tools, as they occur in Early Neolithic sites of SE Europe; pie chart obtained on a total of 30 sites investigated for grinding and pounding stone tools.

time and labour demanding and alternative pounding containers such as pits could have been used (e.g. pit-like mortars constructed in ground depressions lined with clay as observed ethnographically for Morocco, Peña-Chocarro and Zapata 2014; see also Valamoti 2009, 56 for a Neolithic equivalent from Thermi B in Northern Greece). In any case, their presence or absence is unlikely to have been random but rather the outcome of variations in food processing tools, *chaîne opératoires* and desired foodstuffs among the Early Neolithic communities of SE Europe. Such variations therefore may have been related to variable culinary techniques and eating habits. In addition, the relative proportions of the two categories of plant food processing methods (pounding and grinding) might also be the result of complex socioeconomic factors related to household and communal practices.

Grinding and pounding stone tool technology seems well established in the Early Neolithic, mostly in Greece, perhaps as elements of the introduction of the "Neolithic package" (Perlès 2005; Stroulia et al 2017, 22; Tringham 2000). The variation that it is observed on the types of food processing tools, in turn, reflects the significance, intensity and particular characteristics of plantfood processing practices that may correspond to interactions between hunter-gatherer and farming lifeways, as well as experimentation that may have characterized the new ways of plant food procurement and transformation in the Early Neolithic of the region (e.g. exploitation of both wild and domesticated species, Valamoti 2015), yet, this requires further archaeological evidence. Plantfood processing habits and know-how via grinding and pounding were employed at each settlement as the outcome of adaptations to the local environments, the economic parametres and social structure of every group. Eventually, food processing techniques are part of changing subsistence strategies, adaptation mechanisms and culinary identities.

16.6 Grinding and pounding in Early Neolithic: a social event?

Diversities in food processing may not be attributed only to food exploitation habits for the production of daily meals. The significance of each processing method may change when cooking forms part of preparations for special occasions. In our study area, food processing is mostly encountered in habitation zones, either in the interior of domestic units or in open areas between architectural features (Bekiaris et al 2020, Bekiaris et al this volume, Chapter 18). Food preparation apparatus may be portable or permanently fixed in space. The positioning of food preparation tools and structures within settlement space, or even outside its confines, was probably variable reflecting different aspects of food processing as a social practice. In Early Neolithic SW Asia open grinding areas between houses have been reported and they were suggested to correspond to separate spaces dedicated to food processing (Asouti and Fuller 2013). Large mortars, that are considered to be used communally, are found in early pre-agricultural sites in the Jordan valley and the Negev highlands (e.g. Belfer-Cohen and Hovers 2005; Eitam 2008). In phases chronologically closer to the Early Neolithic of our study area, specialized buildings/workshops for grinding have been identified in Early Neolithic Anatolia at sites such as Çatal Höyük (Wright 2014) and Göbekli Tepe (Dietrich et al 2019). At Çatal Höyük ground stone evidence supports the hypothesis that grinding was conducted on a daily basis in household level but at the same time it is documented that, in some instances, groups of people gathered together to grind or pound large quantities of food (Atalay and Hastorf 2006; Baysal and Wright 2005; Wright 2014). Some ethnographic examples also argue in favor of a communal use of mortars (Baudais and Lundstrom-Baudais 2002; Ertuğ-Yaras 2002). This need not have been performed in bulk, but piecemeal, as is the case, for example, of communal pounding for dehusking emmer wheat, in Ethiopia, a regular task that contributed to female bonding (d'Andrea and Haile 2002). The same observation is also reported for cases of grinding equipment being placed on spaces used communally by several grinders operating at the same time (Moritz 1958; Searcy 2005, 36; Storck and Teague 1952).

Among early farmers and herders of prehistoric Greece, communal food preparation has already been suggested (see Nea Nikomedeia: Souvatzi 2008, 70; Knossos: Tomkins 2007, 187; Paliambela: Kotsakis 2018; Achilleion: Gimbutas et al 1989, 46; Halstead 1999). Hearths are found both inside domestic structures and adjacent open spaces, implying cooking indoors and outdoors, often seen as a distinction between the private and public spheres of society (Halstead 1999, 2012). Food processing stone tools have been found in both interior and exterior context[2] (Achilleion: Winn and Shimabuku 1989, 46).

Regarding the social dimension of food preparation, specific cooking techniques and recipes have been linked to practices related both to daily meal preparation and to meals for special occasions. Pounding is associated to burial customs in early preagricultural sites in Jordan valley and the Negev (Rosenberg and Nadel 2014) and there is a close connection of cereal staple foods and the dead, including ancestral worship in different cultural contexts throughout the world (Megaloudi 2006; Valamoti 2011b; Valamoti 2023). In Early Neolithic Lepenski Vir there are indications that the use of stone tools for food processing was not only part of the daily food preparation but associated with the burials that mark the site (Srejović 1972; Srejović and Babović 1981). At Mavropigi-Fillotsairi, carbonized cereal grains were cleaned of their husks before being deposited in the burial fill; this could imply some sort of link between pounding activity for preparing clean grain for the dead and burial rituals connecting ancestral worship and staple cereal grain (Valamoti 2011a).

The estimated function of buildings and pit houses in Mavropigi-Fillotsairi, swapping between the collective and domestic through time (Karamitrou-Mentessidi et al 2015; Kotsakis 2018) considered together with food processing stone tools may suggest that food processing activities at the site obtain a multifaceted social character. If we consider the position of the two mortars that were located in phase II Western Orygma and Ellipsoidal House as indicative of the space were plant food processing took place, we can argue that these activities were performed in certain parts of the site and not everywhere as such tools have not been found inside the Central Orygma or at any other open space of the site. In phase III, the only grinding tool of the assemblage is found *in situ* inside the Central Orygma (a communal building?), while a mortar was found placed inside House I (a household unit?).

The spatial associations of the food processing stone tools from Mavropigi-Fillotsairi and the sparse information from contemporary sites of SE Europe, may suggest a considerable versatility in the function and social role of food preparation stone toolkits in the Early Neolithic, a feature that was in all likelihood strongly related to the social dimension of food processing and the stone tools employed towards this end; such is the case observed for the later phases of the Neolithic (Bekiaris et al 2020) and our study shows that this was also the case in much earlier periods. Multiple and composite factors influence the specific selection of pounding or grinding implements (or both) and their spatial associations: technological traditions or innovations, available raw materials for the making of food processing implements (appropriate stone versus wood, pounding inside pits), presence of available food resources and climate conditions (Ivanova 2018), as well as cultural choices of food ingredients and recipes (cf. Valamoti et al 2017), food procurement strategies (farming or gathering) and economic decisions (Runnels 1981; Horsfall 1983, 61-64), population size and synthesis (Ivanova 2018), the role and significance of food preparation in social structure (Tomkins 2007). In any case, the characteristics and function of food processing stone tools should be co-examined when we consider the Early Neolithic as a phase in the transition from "communal" to "household economy" (Childe 1964, 67; Flannery 2002; Halstead 1999).

2 The detailed excavation data concerning the context of grinding and pounding equipment are few and we need to underline that the location of the archaeological finds does not necessarily coincide with the spaces where they functioned: they could have been moved, depending on season, occasion or activity which they were required (Bekiaris et al this volume, Chapter 18).

16.7 Conclusions

In this paper, we tried to raise the problematic towards variations of food processing practices with pounding and grinding stone tools in Early Neolithic SE Europe. The basis of our study has been established on the rare occurrence of plantfood processing stone equipment from the Early Neolithic site Mavropigi-Fillotsairi, where pounding with stone tools seems to be the preferred practice for food preparation. Under the light of new evidence, we can presume that in Early Neolithic SE Europe, plantfood processing with stone tools doesn't appear uniform characteristics. The selection, shift or exclusion of grinding and pounding techniques reveals aspects of the prevailing Neolithic economic model. Given the variability, we can speculate that different culinary identities might have existed, perhaps also reflecting origins of the first farmers reaching SE Europe. During the course of this spread westwards from Anatolia and the Near East and northwards from the Aegean into the Balkans, modifications and local adaptations were probably under way, resulting in further variability.

Food grinding and pounding practices in the Early Neolithic contribute to the approach of socio-economic interactions among the groups of people, social structures and the process of Neolithic household formation. The interplay between the domestic and communal spheres of food preparation, documented more securely through stone tools later in the Neolithic, is particularly noticeable in Early Neolithic, based on our observations. This interaction emerges as equally complex and diverse among early farmers of SE Europe on both the social and technological sphere. Variable eating habits and practical solutions, meanings and symbolisms concerning food become evident through stone tools used for plantfood preparation, allowing glimpses of the complex processes and changes underway involved in the emergence of Neolithic way of life.

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Chapter 17

Grinding practices in prehistoric north and central Greece: evidence from the use-wear analysis

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Abstract

Grinding technology is an integral part of the prehistoric material culture, implicated in various food-processing and craft activities. Over the last two decades research on grinding stone toolkits has demonstrated the existence of divergent technological choices and traditions, as well as the importance of specialised studies in highlighting this variety. In this framework, the first extensive use-wear analysis performed on selected artefacts from various prehistoric settlements in north and central Greece has a significant impact on our understanding of past grinding systems. A multi-scale use-wear analysis conducted with various means of observation and in multiple magnification scales (stereomicroscopy, metallographic microscopy, confocal microscopy) enabled the identification of specific use-wear patterns and their correlation to particular uses. The results revealed a palimpsest of diverse practices and traditions regarding the manipulation and use of grinding implements. Multifunctional tools employed in various tasks (e.g. processing of a variety of organic matter) coexist with tools reserved for specific functions (e.g. processing of oily substances) as well as secondarily used or recycled artefacts incorporated into new contexts of function. Diverse food processing methods and practices, such as the grinding of cereals with or without prior dehusking, suggest the existence of different technical choices for the same activity, while the typological and morphometric diversity of grinding equipment testified on an intra- and inter-site level has a possible functional dimension that needs further investigation. Overall, a much more generalised tendency for secondary use and recycling of the grinding gear is evident in the Bronze Age assemblages, a practice that may be coupled with a diachronic amplification of the range of functions of the grinding tools. If not associated with economic factors such as the introduction of new species into the range of human-exploited plants, it could be an indication of social changes.

Keywords: *grinding tools, use-wear, functional analysis, Greece, Neolithic, Bronze Age*

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17.1 Introduction

Grinding tools have appeared as early as the Palaeolithic times (e.g. Dubreuil and Nadel 2015; Revedin et al 2010), but it was during the Neolithic period, the period of a gradual transition to the new agropastoral lifeways and the establishment and proliferation of sedentary farming communities, that their number and types multiplied marking a revolution in this technological sector. This was by no means a homogeneous process. Instead, numerous case-studies bring to light intriguing particularities underscoring local and inter-regional divergences in the grinding technological systems, their associated activities and their ascribed values (e.g. Bofill 2015; Hamon 2008a and b; Hamon et al 2011; Jaccottey 2011; Runnels 1981; Wright 1994, 2000). Such research outcomes highlight the importance of detailed material analysis as well as regional and diachronic comparisons in order to identify broader patterns pertaining to technological, socioeconomic and cultural aspects of past societies. This is particularly demanding, however necessary, in the case of grinding technology, where an apparent morphotypological uniformity may often render variations and changes undetectable at first glance.

Contrary to deeply rooted perceptions, grinding implements do not relate exclusively to cereal processing or even food-processing in general. Instead, they have a wide range of functions for a better understanding of which much research is being invested over the last two decades. The identification of particular wear patterns on the tools' use-surfaces in combination with the recovery of microbotanical remains and experimental explorations have proven invaluable lines of inquiry in the context of deciphering the way these implements were manipulated and used (e.g. Adams et al 2009; Bofill et al 2013, 2014; Dubreuil 2002; Hamon and Plisson 2008; Liu et al 2010; Portillo et al 2013; Procopiou 1998; Veth et al 1997).

Partly in analogy with the history of research elsewhere in Europe and the New World, the research in the field of grinding tools and ground stone technology as a whole in Greece, after remaining limited for many decades, is now witnessing increasing activity. Although in many -mostly generic- publications grinding tools are still being by default directly or indirectly associated with food processing activities without any other supporting evidence, innovative research attempts have made their appearance. Functional analyses (Poursat et al 2000; Procopiou 1998, 2013; Procopiou et al 1998; Stroulia and Dubreuil 2013; Stroulia et al 2017) are sporadic and thus still far from matching in frequency the techno-typological studies, they have, however, laid the necessary foundations for further research in this promising field. Most importantly, they have proven the central importance of understanding the tools' function(s) in order to gain a deeper insight into the economic organisation of past societies, their technological choices and established traditions.

The present paper offers an overview of the methodology applied and the results obtained in the context of the first extensive and systematic functional analysis of grinding stone tools from Greece, developed as part of the multidisciplinary approach to prehistoric culinary cultures of southeastern and central Europe within the ERC-funded PlantCult project (Valamoti et al 2017). Selected grinding stone tools from nine prehistoric sites of north and central mainland Greece have been analysed and the obtained data have been merged together into a large-scale comparative synthesis. The results revealed a palimpsest of practices and traditions regarding the manipulation and use of these implements. Diverse food processing methods and practices, such as the grinding of cereals with or without prior dehusking, indicate the existence of different technical choices, while intra- and inter-settlement typological and morphometric diversity of the grinding equipment is attested, with possible functional connotations.

17.2 Methodology

The study of use-wear traces -i.e. the detailed observation of various function-related changes on the use-surface of a tool, and, based on them, the attempt to draw conclusions about its function- requires the application of multiple levels of analysis as well as an experimentally produced use-wear reference guide.

The multi-scale use-wear analysis applied in the context of our research comprises two essentially complementary parts, a qualitative and a quantitative analytical stage. It builds upon several studies previously developed on the functional and 3D analysis of wear on archaeological and experimental grinding stone tools as well as standardised terminology (Adams et al 2009; Bofill et al 2013; Dubreuil 2002; Procopiou et al 1998; Vargiolu 2008).

17.2.1 Qualitative analysis

The qualitative stage includes observations with the naked eye and different optical devices (stereomicroscope and metallographic microscope) at different magnification scales.

The general topography of the use-surface of a tool and the distribution of manufacture and use-wear traces are first described on a macroscopic scale. The observations at this level of analysis are important as they allow the identification of the use-surfaces of a tool, its active or passive role during the grinding process (i.e. whether it is used as a handstone or a quern), the kinematics involved (e.g. abrasive use in a back-and-forth rectilinear or "free" curvilinear motion; a combination of abrasive and percussive use), its mode of handling or placement, the general patterns of use-wear evolution on the overall surface topography, the existence of special function-related morphological traits (e.g. concentration of percussion marks related to use and not manufacture;

existence of facets). Moreover, these first-level naked-eye observations allow us to synthesize the following steps of analysis that involve the application of magnifying optical devices (Dubreuil et al 2015, 146).

On level 2, the observation of the wear traces on the tools' use-surfaces is conducted with a stereomicroscope with magnifications up to 100x. Aspects of wear formation detected in a microscale, i.e. microrelief and individual grains, are analysed (e.g. fractures, pits, grain fracturing and extraction, grain rounding, levelling, linear traces, polish). Further characteristics of these distinct traces, such as their location over the surface topography and their distribution, density, morphology, texture, depth, and orientation, are also recorded since they are directly related to the wear mechanisms that caused the surface alterations (see Rabinowicz 1965).

The last level of analysis focuses on micro-scale use-wear traces observed with a metallographic microscope in high magnifications (50x-500x) on the highest and smoothest plateaus of each surface sample and more specifically on the polished zones. Polish is a highly diagnostic use-wear trace; different types and characteristics of micro-polish are associated with different materials processed on each tool's surface (for the qualitative classification of micro-polish into micropitted, deposit and serrated see Bofill et al 2013; Verbaas and Van Gijn 2007).

17.2.2 Quantitative analysis

In order to move from qualitative to quantitative assessments, surface measurements are conducted with the use of a confocal rugosimeter. It combines a confocal microscope and an optical device that projects different wavelengths of white light on different points of the surface, in order to measure its topography. For this level of analysis silicon casts are made from selected parts of the tools' surfaces since the equipment used does not allow the examination of bulky artefacts.

Initially a laser sensor of 2,5 mm is used to scan a 14 mm × 14 mm area per sample to provide us with a statistical representation of the whole surface analysed. These macro-measurements provide information about the general aspects of the high and low topography. On the micro-scale analysis three much smaller areas (500 μm x 500 μm) inside the area initially scanned are measured with the use of a laser sensor of 400 μm. Focus is placed specifically on the polished areas of the topographic highs. The average measurements of these areas offer a statistical representation of the topographic highs of the area analysed.

Finally, the obtained data are subjected to statistical treatment. The method of the continuous wavelet transform decomposes the surface in different wavelengths of roughness and provides information on the roughness, waviness and form of the measured surface (Lee et al 1998). The SMa coefficient represents the arithmetic mean value of the multi-scale decomposition of a surface. Previously applied in other wear analyses (Bofill 2015; Bofill et al 2013; Procopiou et al 2011; Vargiolu 2008) it proved valuable in reflecting different use-wear signatures depending on the substances each tool processed.

Overall, the applied methodology combines optical microscopic analysis and surface measurements and characterisation for distinguishing different types of micropolish and for achieving accurate identifications of the materials processed with the analysed implements, allowing for a more comprehensive, holistic approach of their functions. In the context of our research, residues have also been extracted from both the experimental and the archaeological tools. Therefore, in a second stage, the data from the use-wear analysis will be correlated with the information obtained from the microbotanical analysis (phytoliths, starch grains). The results from this integrated approach will be presented elsewhere, whereas the current paper will focus solely on the use-wear analysis.

A functional interpretation must take into account certain limitations. First of all, grinding tools may have long use-lives and complex biographies, as multiple ethnographic studies show (e.g. Horsfall 1987; Hamon and Le Gall 2013). The context of use, the users and, above all, the functions and mode of use of these tools may change throughout their use-lives, which may reach up to several decades. Over these long life-cycles, secondary use(s) -with or without prior refashioning- and recycling of the tools are common practices and should be anticipated. The overlay of functions that these practices entail may not always leave detectable traces and the identified use-wear traces may correspond to the tool's last use, obliterating signs of previous functions. Repecking, a repeated process of rejuvenation of the use-surface of a tool through the renewal of its abrasiveness, would also mean the removal of parts of the surface and, therefore, of use-wear traces. Hence, the identification of separate episodes of use and their relation to each other in terms of sequence of occurrence may prove particularly challenging (see also Dubreuil et al 2015). Finally, the substances processed with the grinding implements do not represent the whole range of substances exploited. Not all plant species, and organic substances in general, were subjected to processing through techniques of grinding and pulverizing, and those that were, may have been done so with different equipment. Stone grinding implements formed just a part of the prehistoric toolkit available for the performance of food-processing and other activities. They would have been complemented by a series of other artefacts from other materials, such as wooden pestles, wooden or earthen mortars and cupstones for pounding actions.

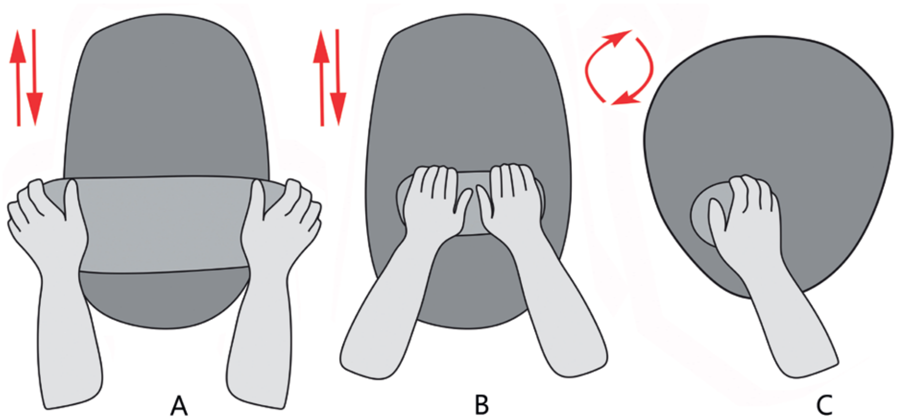


Fig. 17.1 Three main grinding tool types identified in the area under study (after Chondrou 2018).

17.3 Grinding experiments

For an experimental investigation of grinding stone technology, different types of tools, of various raw materials and sizes were manufactured and used (Appendix 17.1 and 17.2; for an analytical presentation of the experimental program and the various factors examined see Bofill et al 2020). Three basic tool types, identified in the archaeological record (Chondrou 2018, 147-150; 2020, 289-290, 294-295), have been selected and experimentally reproduced: a) a quern paired with an elongated handstone, whose length exceeds the width of the quern, used in a rectilinear, reciprocal back-and-forth motion; b) a quern paired with a smaller handstone (length smaller than the quern's width), also in a rectilinear, reciprocal back-and-forth motion and c) a quern paired with a smaller handstone (length smaller than the quern's width), used in a "free", curvilinear motion (Fig. 17.1). Experimental querns were designed in such a way, so as to replicate two different size-groups: one "small" with a length less than 30 cm and one "big" exceeding 30 cm in length (see Appendix 17.1 for tools' dimensions). The conventional 30 cm limit was employed in order to reflect different trends found in the archaeological record (i.e. the existence of small-sized as well as much larger tools, for a discussion of the observed image in Greece see Valamoti et al 2013; Bekiaris et al 2020). The raw materials used for the tool manufacture (sandstone, andesite, granite) were chosen based on their frequency of appearance in the archaeological assemblages, in a manner that represents the main geological categories. These rock types have different mechanical properties such as degree of surface roughness, cohesion, hardness and resistance to friction, parameters that certainly affect the grinding process (Delgado-Raack et al 2009). The general shaping of the experimental tools was done with mechanical means, whereas the active surfaces of both querns and handstones were prepared by pecking with different hammerstones (see Bofill et al 2020).

Thus, the experimental tools, in terms of raw materials, size, shape and type, constitute a representative sample of the variability of grinding tools observed in the archaeological record of the area under study. A wide range of plant ingredients (cereals, pulses, oilseeds and nuts), with various pretreatments (dehusking, splitting, boiling, soaking, drying, roasting etc), were ground in order to explore the resulting use-wear and associated plant micro-remains (starches and phytoliths). These, too, correspond to the archaeobotanical findings in the study area (see Heiss et al 2017; Stika and Heiss 2013; Valamoti 2009, 2011; Valamoti et al 2013, 2017). One of the main goals of the experimental program was to generate a series of use-wear patterns that can be directly linked to the processing of various plant-species in order to function as a reference guide for the analysis of the archaeological grinding implements. No experiments have been conducted with non-plant materials. For the identification of related wear patterns, we relied on previous research (e.g. Bofill 2015; Dubreuil 2004; Dubreuil and Grosman 2009; Liu et al 2010).

17.4 Use-wear analysis of archaeological grinding tools: selected sites and samples

The sample for analysis originates from nine sites of the Greek mainland (Fig. 17.2): Early Neolithic Ayios Vlasis, central Greece (Dimaki and Souvatzi 2012); Early Neolithic Mavropigi-Fillotsairi, north-western Greece (Karamitrou-Mentessidi et al 2015); Middle/Late Neolithic Stavroupoli, central Macedonia (Grammenos and Kotsos 2002, 2004; Grammenos et al 1997); Late Neolithic Koroneia (Kotsos and Tselepi 2020, in press); Late/Final Neolithic Kleitos in north-western Greece and a much later, Middle Bronze Age pit that cuts through the Neolithic strata (Ziota 2014a and b; Ziota et al 2013); Neolithic/Bronze Age Dikili Tash in eastern Macedonia (Darcque et al 2007; Darcque 2013; Koukouli-Chryssanthaki and Treuil 2008); Early Bronze Age Ayios Athanasios (Pappa et al 2000; Mavroeidi et al 2006;

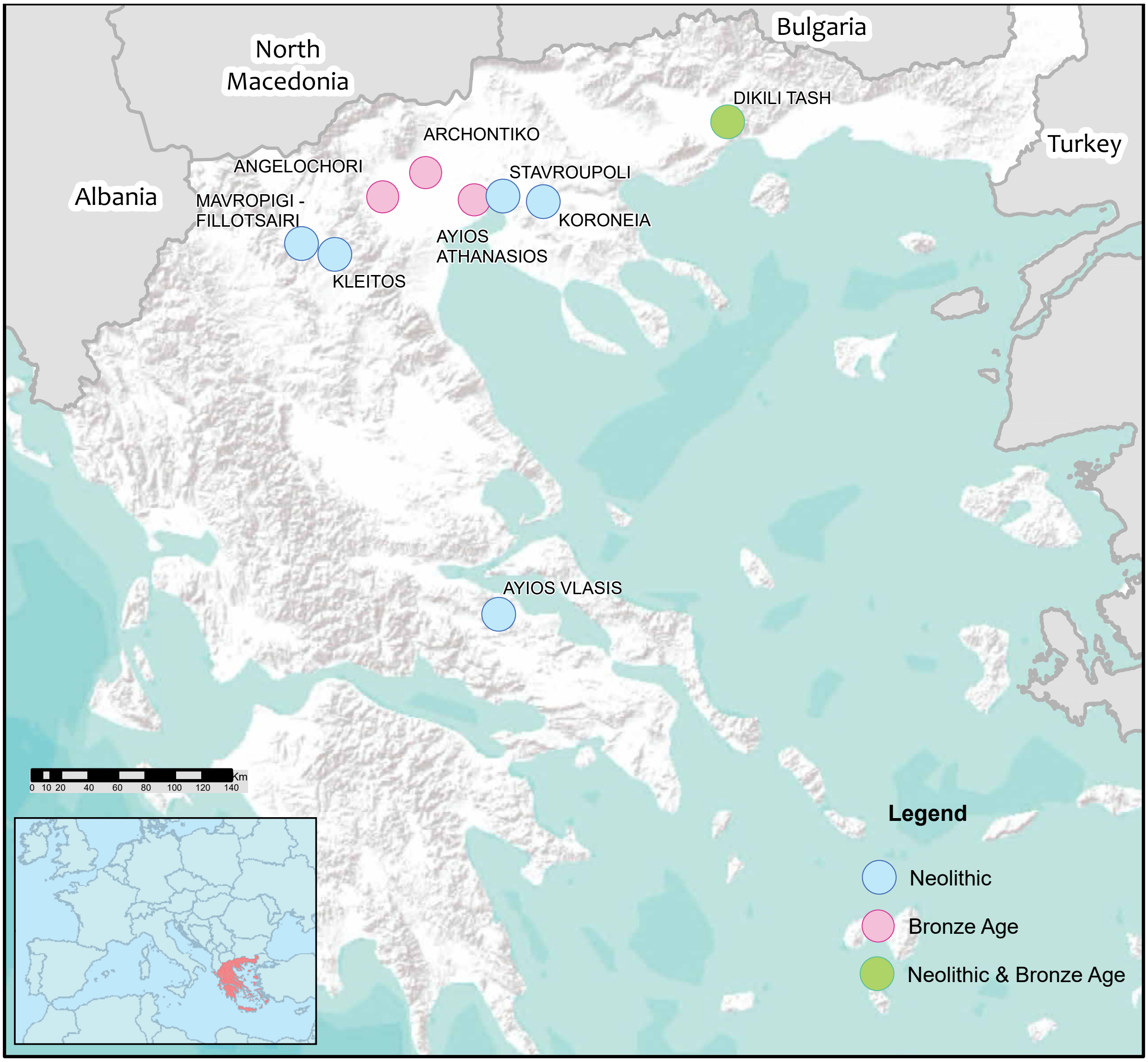


Fig. 17.2 Map with the nine Neolithic and Bronze Age sites from which the grinding implements analysed originate (Kleitos is marked as Neolithic since the Bronze Age pit does not represent a later phase of the specific settlement) Basemap sources: Esri, US Geological Society, and National Oceanic and Atmospheric Administration. Map prepared by Themis Roustanis.

Mavroeidi 2012); Bronze Age Archontiko (Papadopoulou et al 2010; Papaefthymiou-Papanthimou 2010, Pilali-Papasteriou et al 2001) and Late Bronze Age Angelochori (Maniatis 2010; Stefani 2010; Stefani and Merousis 2010), all last three located in central Macedonia, northern Greece.

Table 17.1 shows the size of the samples selected for use-wear analysis per site. Overall, a total of 112 grinding tools have been selected. Yet, due to the unforeseen Covid-19 situation, the quantitative analytical stage could not be performed for a subgroup of 41 specimens. A detailed list of the items fully analysed is given in Appendix 17.4. They include querns and handstones of all three basic tool types (see previous section about grinding experiments), with different morphometric traits, used with various kinematics, made of a variety of raw materials. The choice of artefacts was based upon their preservation status, their context of retrieval and their typology. Seldom did the selection strand afar from these criteria, and that was only due to the high significance of the archaeological context or due to peculiarities of the artefact, worthy of further analysis. Therefore, the majority of the analysed specimens are intact or nearly intact. The use-surfaces are well preserved, even in those cases where the tools have been exposed to fire.

SITE	PERIOD	DATE BC	TOTAL NUMBER OF GRINDING TOOLS	NUMBER OF GRINDING TOOLS ANALYSED	PERCENTAGE OF TOOLS ANALYSED
Mavropigi-Fillotsairi	Early Neolithic	6600-5900	1	1	100%
Ayios Vlasis	Early Neolithic	6700/6500-5800/5600	7	7	100%
Stavroupoli	Middle-Late Neolithic	5800/5600-4700/4500	59	9	15.25%
Koroneia	Late Neolithic	5400/5300-4700/4500	49	6 (9*)	12.2% (18.4%*)
Dikili Tash	Early Neolithic-Late Bronze Age [Late Neolithic]	6678/6409-1374/1187 [5500-4000]	82	11 (32*)	13.4% (39%*)
Kleitos and pit of later dating	Late-Final Neolithic (settlement) and Middle Bronze Age (pit)	5400/5300-3300/3100 and 2300/2200-1700/1500	614	7 (24*)	1.1% (3.9%*)
Ayios Athanasios	Early Bronze Age	3300/3100-2300/2200	73	16	21.9%
Archontiko	Early-Late Bronze Age	2135/1890-1510/1400	123	10	8.1%
Angelochori	Late Bronze Age	1630/1495-1350/940	14	4	28.6%

Table 17.1 Sites examined, archaeological phases and dates (after Andreou et al 2001, Table 1; and for the sites with available radiocarbon dates: Darcque et al 2021; Karamitrou-Mentessidi et al 2015; Pilali-Papasteriou et al 2001; Stefani and Merousis 2010), total number of grinding implements found at each site, number of analysed specimens and percentages. An asterisk marks the total number of objects analysed, including specimens that due to COVID-19 constraints were not subjected to the quantitative analysis. In the case of Dikili Tash, the date of the sample analysed in the current study is given in brackets.

17.5 Results

17.5.1 Experimental data: Observations per level of analysis

17.5.1.1 Qualitative analysis

17.5.1.1.1 Levels 1 and 2 – Macroscopic and microscopic observations of use-wear traces

The optical analysis of the experimental tools' surfaces allowed the detection of distinct wear patterns related to the processing of different materials. Cereal processing resulted in the formation of plateaus with rounded or flat-rounded cross-section and low roughness, low/medium polish development and thin, short striations. The low topography remains highly irregular, with some low rounding of separate grains. When cereals are processed in their hulled form (i.e. the grains still inside their hard husks) the plateaus on the tools' surfaces are smaller, sparser, of a more sinuous morphology, with low rounding of the grains, low polish and no linear traces. In the case of millet, the plateaus of homogenous microtopography on the tools' surfaces were more extensive and with a more reflective polish compared to the ones formed through einkorn and barley grinding. An intense dark coloration was found to be associated with the most worn areas of the tools' use-surfaces, a trait noted as well in oilseed and nut processing with sandstone tools (Bofill et al 2020) and in legume grinding with basalt tools (Dubreuil 2004), but unprecedented for cereal processing. In these areas, there was a characteristic alignment of small pits forming scratches that follow the direction of the tools' motion. Legume grinding, on the other hand, produced extensive microfractures and flattened plateaus with low polish and no striations. The processing of greasy ingredients such as acorns and oil seeds was associated with darker, highly polished surfaces with intense rounding of single grains in high and low topography. The series of diagnostic use-wear traces generated by the experimental grinding program are summarized in Appendix 17.3. A more detailed description of the experimental results can be found in Bofill et al 2020.

Low magnification analysis of the experimental surfaces also showed the effect of tool movement (i.e. the orientation of the grinding strokes) on wear patterns. The circular motion of the handstone in tool type 3 creates rounded plateaus on tools' surfaces. In contrast, the back-and-forth rectilinear motion of the handstone in types 1 and 2 tends to create flatter plateaus with sharp edges (Bofill et al 2020).

17.5.1.1.2 Level 3 – Microscopic observation of polish

The observation of polished surfaces on the microtopography of the tools with a metallographic microscope allowed the detection of three basic types of polish: micropitted, deposit and serrated (Fig. 17.3). These types of micropolish have been identified in previous studies on use-wear analysis as well and their relation to particular functions has been highlighted (Bofill et al 2013). Our analysis has validated the association between the micropitted type of polish and the processing of cereals, the deposit type and the processing of legumes and greasy matter, and the serrated type with the stone-against-stone friction.

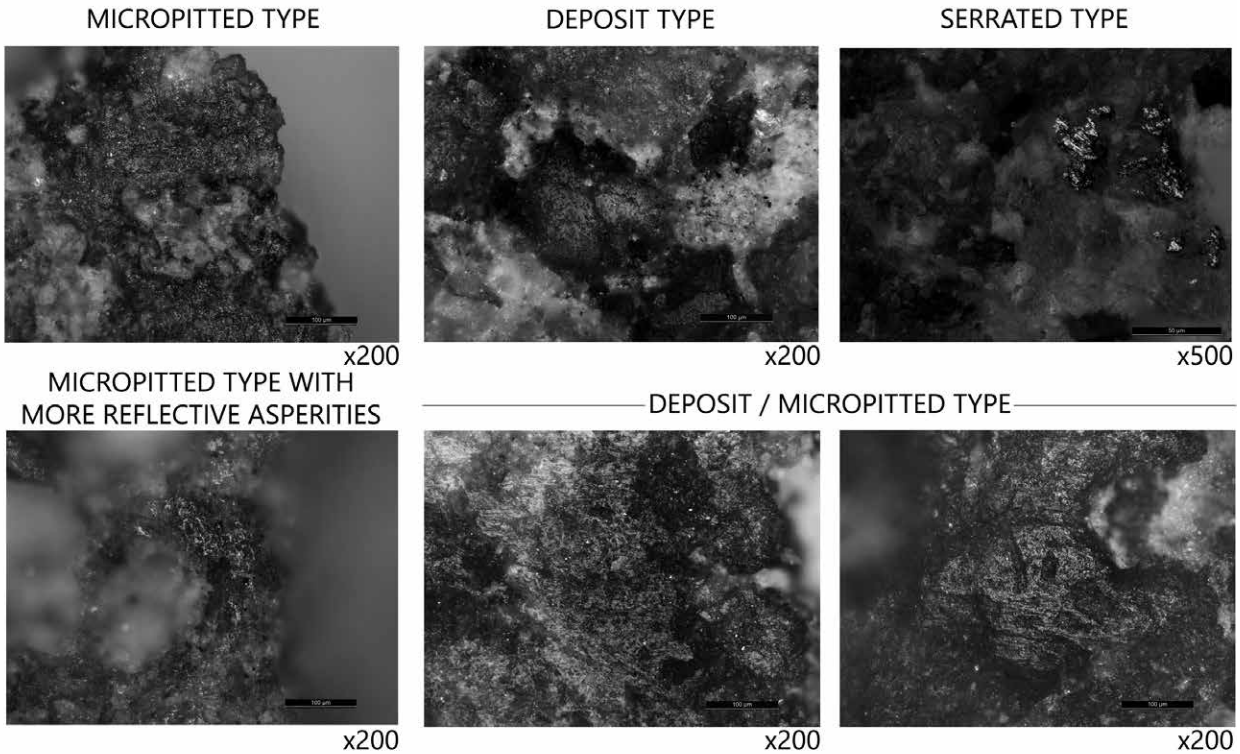


Fig. 17.3 Different types of micropolish identified on archaeological specimens from various sites (photographs taken with a metallographic microscope at the magnification indicated under each picture).

17.5.1.2 Quantitative analysis

Comparing the data obtained from the 3D surface measurements with a confocal microscope and the characterization with the method of the continuous wavelet transform of tools used to process similar plant ingredients but made of different rock types (i.e. raw material) yielded significantly different degrees of wear and important variations of their micropolish. Fig. 17.4 shows different wear signatures generated by two experimental tools made of andesite and sandstone, both used to process dehusked einkorn. Instead of the homogeneous results anticipated, the SMa coefficient differs significantly reflecting the difference in the raw material of the grinding stone tools. It follows that the attributes of wear formation are drastically affected by the stone type and not only by the ground matter.

Focusing on the subgroup of the experimental specimens that were made out of the same raw material and used to process cereals, they also yielded different wear signatures depending on whether the cereals were husked or dehusked. The surfaces of the tools used to process hulled cereals have produced higher SMa values (Fig. 17.5). Husks seem to function as an abrasive agent between the quern and the handstone, conducing to the formation of rougher surfaces. These results are in concordance with the aforementioned optical observations.

Since stone raw material proved to be a parameter that heavily affects wear formation, comparisons of the SMa coefficient should be made between tools of the same stone type. In the case of experimental data, comparisons should also be made between tools used for the same amount of time since use-wear formation is a cumulative process inextricably linked to the duration of use. When comparing, for example, the same tool employed in grinding dehusked einkorn wheat after 4 and 5 hours of use respectively, shorter use time is found to produce higher SMa values. This is due to the smaller degree of wear developed and, therefore, the lesser bearing area formed, i.e. plateaus and flattening of asperities (see Procopiou et al 1998). In our experiments, we focused our comparisons on tools' surfaces with the maximum duration of use (i.e. 5 hours for experiments 1 and 2, see Appendix 17.2).

The comparative analysis of the SMa coefficient wavelengths from experimental tools manufactured from the same stone type and used for the same amount of time to process different materials revealed a certain "stratigraphy" in the SMa coefficient distribution. The highest curves represent cereal processing (the husked cereals give even higher values, Fig. 17.5), lower curves represent legumes and, lastly, greasy substances show the lowest values (Fig. 17.6). This indicates that cereal

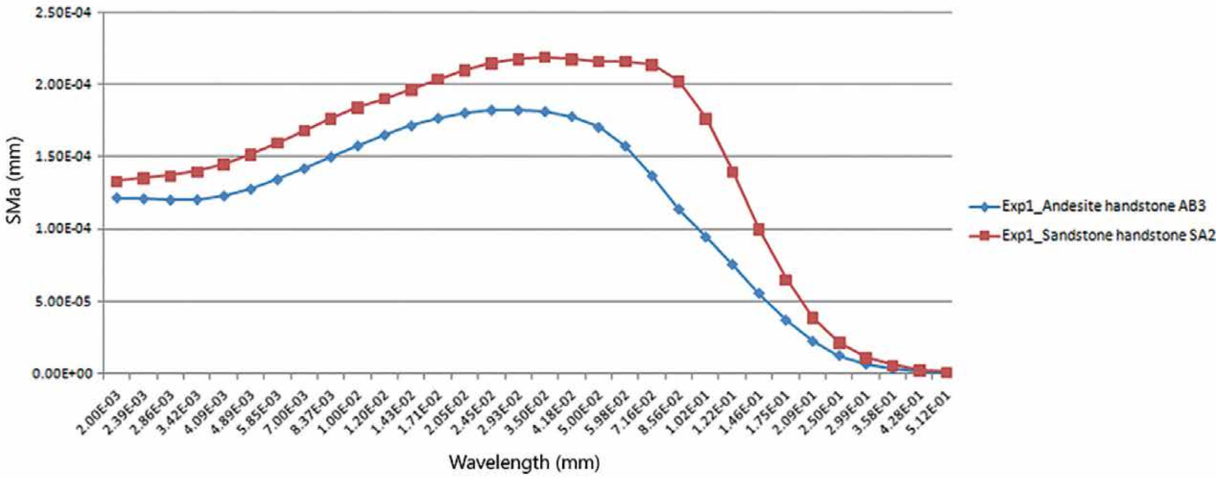


Fig. 17.4 SMa decomposition applied on experimental tools used to grind dehusked einkorn. Although the specimens had the same function, their results differ significantly reflecting their different raw material, sandstone and andesite (after Chondrou et al 2021).

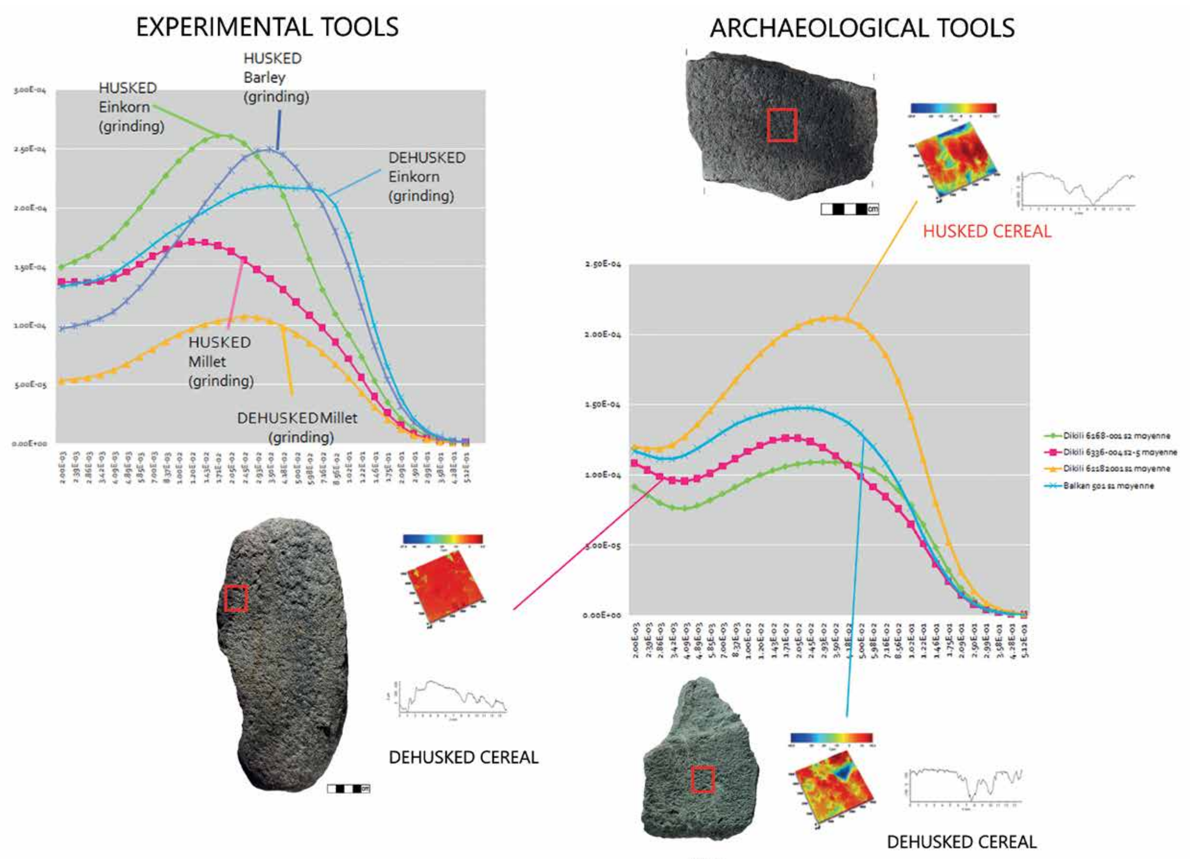


Fig. 17.5 SMa results from experimental grinding tools used for grinding husked and dehusked cereal (left graph) and SMa results from sampled archaeological tools from various sites, all considered to have been used for processing cereal in dehusked and husked form. Note that the SMA wavelengths from tools related to husked cereal processing have the highest values.

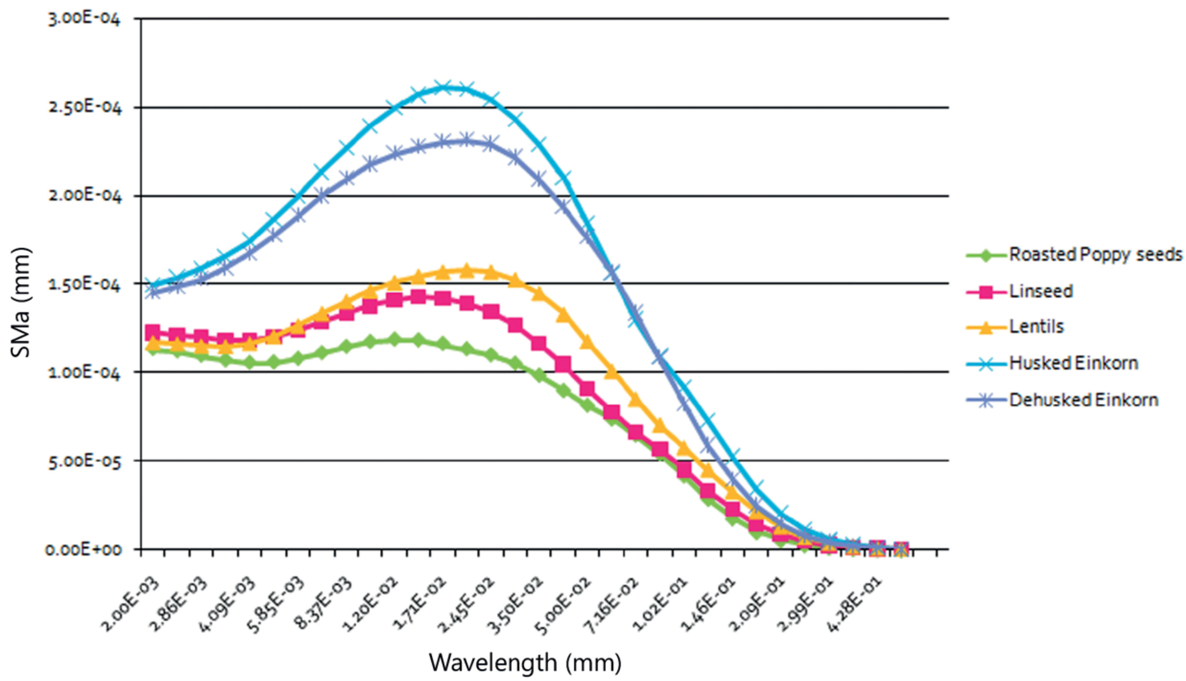


Fig. 17.6 SMa decomposition applied on experimental grinding tools made of sandstone and used for the processing of various substances.

processing results in the roughest type of micropolish compared to the much smoother micropolish surfaces generated by oily substances.

17.5.2 Archaeological data: Observations per level of analysis

17.5.2.1 Qualitative analysis

17.5.2.1.1 Levels 1 and 2 – Macroscopic and microscopic observations of use-wear traces

The archaeological querns and handstones examined showed traces of working in a back-and-forth or circular motion, representing all three basic tool types identified in the archaeological record. They all exhibit pecking on their use-surfaces and signs of rejuvenation episodes (i.e. repecking), except cases of tools being secondarily used for other purposes. Only a few implements in the selected sample present use-wear traces related to an isolated function (i.e. not in pairs), either as passive abrasive surfaces or as active, hand-held abrading/polishing tools. Based on our observations at low magnification and having as a reference guide the results of our experimental program (Bofill et al 2020), along with previous work on use-wear analysis, we were able to formulate functional hypotheses. Use-wear traces possibly related to cereals, legumes, greasy plant-substances and non-plant matter, such as minerals, have been identified (Fig. 17.7 and Appendix 17.4).

17.5.2.1.2 Level 3 – Microscopic observation of polish

All three basic types of micropolish (micropitted, deposit and serrated) have been identified in the archaeological samples analysed. Furthermore, we were able to distinguish a subtype of the first type of polish, a polish with micropitted texture and more reflective asperities, and to successfully correlate it, through its comparison with the experimental data, with the processing of husked cereals. Finally, a combination of micropitted and deposit types of polish that has been observed in a number of tools suggests a secondary use or a multifunctional character for these specimens (Fig. 17.3 and 17.7).

17.5.2.2 Quantitative analysis

The macro-scale 3D topographic measurements conducted with the confocal rugosimeter and a laser sensor of 2,5 mm on the archaeological specimens highlighted further attributes of wear formation related to the kinematics of the tools. The majority of the analysed archaeological tools were used in a linear reciprocal motion. Indeed, the relief profile that coincides with the axis of motion of the tool itself, in the case of a handstone, or its paired implement, in the case of a quern, is higher (i.e. the asperities are more elevated and the elevational difference between topographic highs and lows is greater) and presents greater rounding (Chondrou et al 2021, Fig. 17.8). This observation has its merits in the case of tools whose active or passive role is uncertain due to fragmentation rate.

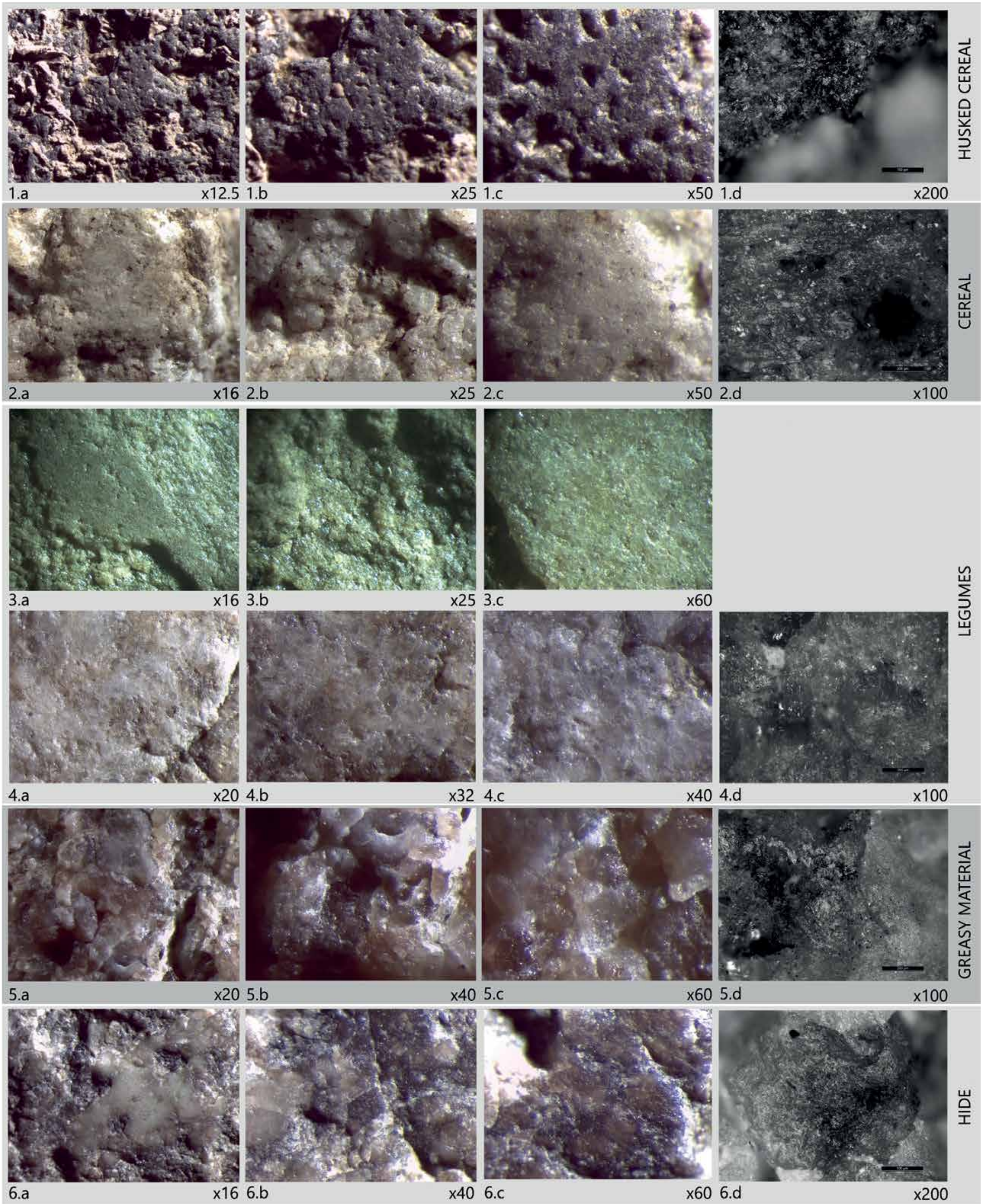


Fig. 17.7 Types of use-wear associated with the processing of cereals, legumes, greasy matter, and hide observed on various archaeological specimens from various sites. Observations with a stereomicroscope and a metallographic microscope (photographs originally taken at the magnification indicated under each picture).

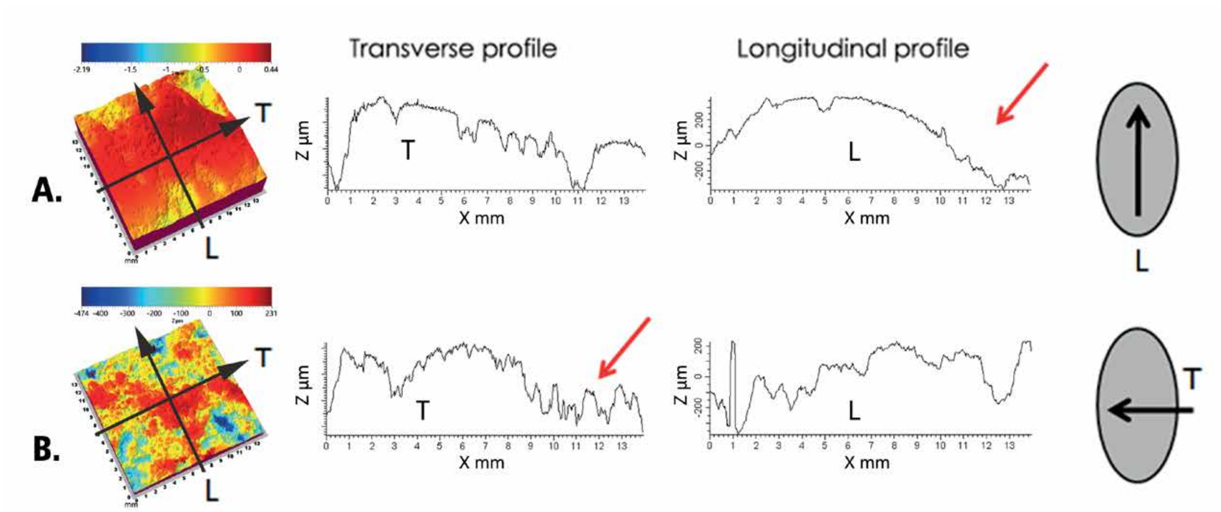


Fig. 17.8 Macro-scale surface measurements and profiles from two different archaeological specimens, showing the influence of kinematics on wear formation: the profile coinciding with the axis of motion of the tool -indicated with an arrow- is higher and rounder compared to the profile of the other axis (modified from Chondrou et al 2021).

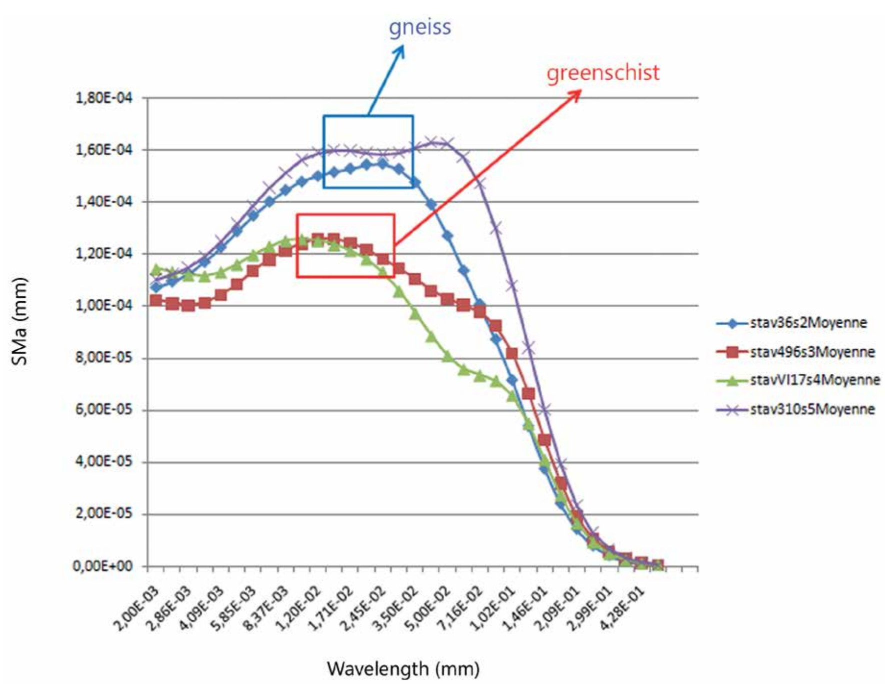


Fig. 17.9 SMa decomposition applied on handstone surfaces from the Stavroupoli assemblage that exhibit use-wear associated with cereal processing. Two distinct subgroups are formed, the one represents tools made of greenschist (stavVI17s4 and stav496s3) and the other one tools made of gneiss (stav36s2 and stav310s5) (modified from Chondrou et al 2021).

Comparing the SMa coefficient of the archaeological tools under analysis yielded, as in the case of the experimental tools, divergences related to the raw material variation and not only to functional factors (Fig. 17.9). For a comparative analysis of the SMa coefficient wavelengths between archaeological specimens or between experimental and archaeological tools, all specimens need to be of the same raw material. The examined archaeological specimens were made of gneiss, sandstone, conglomerate, schist, basalt, granite and a few ophiolitic rocks. Our experiments were conducted with tools made of sandstone, andesite and granite. The granite implements, however, showed a very low degree of wear and, therefore, were considered statistically not comparable to the archaeological ones. The fact that there is a specific sequence in the SMa values depending on the particular matter processed by each tool is exactly what allowed us to benefit from the SMa coefficient analysis even in those cases where the raw materials of the archaeological specimens were not compatible with the experimental ones from our comparative collection, but the samples were plenty enough to form a sequence. Based on the sequence of the SMa curves, we were able to test the

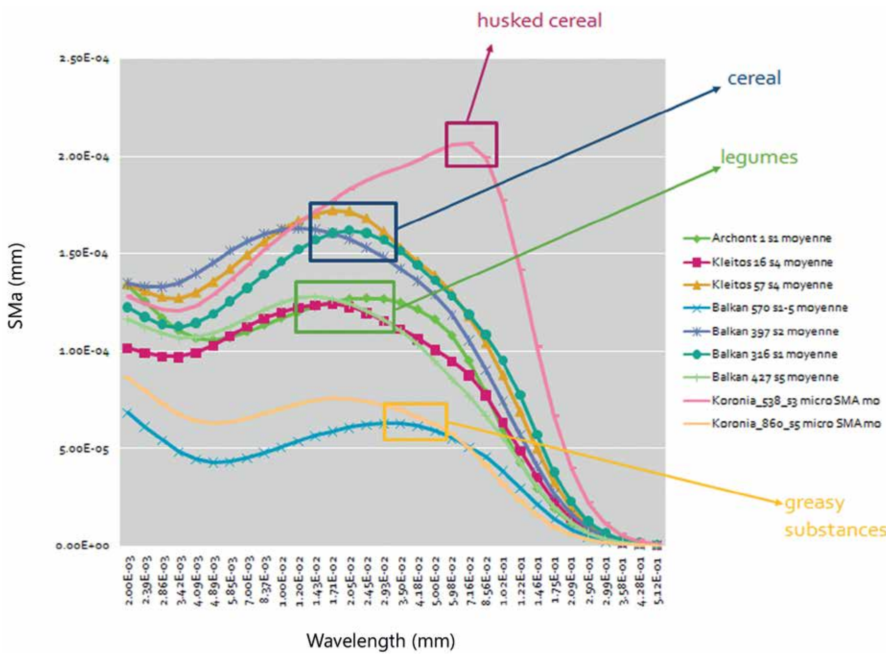


Fig. 17.10 SMa decomposition applied on grinding tools made of gneiss from various sites. The SMa wavelengths present a clear clustering since implements associated with the processing of similar matter yielded similar curves.

functional hypotheses we had formulated on the basis of the observations made in the previous stages of our analysis. From these, the samples originating from implements made of gneiss material generated the clearest results, i.e. patterned sequences of SMa curves forming distinct groups that reflected different tool functions (Fig. 17.10). On the other hand, separate functional groups are less clearly distinct in the sequences yielded by the schist samples. This could relate to intrinsic traits of the raw material itself: mica is a soft ingredient and often presents mass loss after the grinding process, resulting in surfaces with a rougher texture, dense pits and crevices preventing the creation of extensive and smooth homogeneous zones.

17.5.3 Results per site

The Early Neolithic settlement of Mavropigi-Fillotsairi, although fully excavated, yielded a very limited pounding/grinding tool assemblage: four mortar-like tools and only one grinding implement with a flat working surface, a type 1 handstone (see also Ninou et al this volume). They have been recovered from various contexts: open-air spaces, a pit and a dwelling. The use-wear analysis conducted on this single specimen pointed towards legume processing: on a macroscopic scale the use-surface has a rough texture with the development of homogeneous flattened areas in certain areas of higher abrasive wear (Fig. 17.7.3a-3c). Microscopically the extensive plateaus present flattened summits and some rounding of their contours, signs of chipping, polish of medium reflectivity and visible striations. On the other hand, the 4 mortar-like tools in the same assemblage are very interesting if we consider the general scarcity of stone mortars in Greek Neolithic assemblages (Bekiaris et al 2020). These implements have rather shallow cavities, with use-wear traces that suggest a combination of grinding and pounding actions of varied intensity, possibly in association with wooden pestles (with one possible exception). Some have clear signs of successive episodes of use and re-use, even after breakage. The preliminary results from the starch and phytolith analysis from one of the mortars reveal the processing of husked cereals (Kasapidou pers. comm.). Therefore, what we have, so far, is an early farming community where the pounding tools are dominant, at least one of which is associated with the processing of husked cereal, while the sole example of grinding equipment with flat use-surface presents use-wear that links it to legume-processing.

The sample from Early Neolithic Ayios Vlasis includes seven type 1 querns and handstones of generally small dimensions. The majority of the analysed specimens were found in an open area in association with an elliptical clay platform, indicating a probable food-processing area (Dimaki and Souvatzi 2012, 1122). Four out of five handstones have two use-surfaces and five out of seven tools show signs of intensive/extensive use. They all bear use-wear traces associated with cereal grinding, two of them related with the processing of husked cereals (Fig. 17.7.1a-1d, Chondrou et al 2021). One of the handstones shows signs of secondary use as a passive abrasive surface. It is noteworthy that the small excavation of Ayios Vlasis yielded also a significant number of pestles (Chondrou pers. observ.), few of which have been sampled for microbotanical analysis.

The sample from Middle/Late Neolithic Stavroupoli originates from a small area of the settlement, from both Middle and Late Neolithic strata and includes querns and handstones of all three basic tool types (Ninou pers. observ.). Most of the implements show signs of intensive/extensive use, some being (almost) worn-out, and one bears traces of reshaping and secondary use. All nine implements that comprise our sample present use-wear associated with cereal grinding. In three of them, the observations suggest processing cereal in their husked form (Chondrou et al 2021).

The sample from Late Neolithic Koroneia (Almasidou 2019) comprises seven type 1 handstones and querns, a single type 2 handstone and an abrader that morphologically resembles a handstone. They originate from the interior of pit-dwellings as well as from external spaces. The majority yielded evidence of cereal processing, but there are also isolated instances of tools associated with husked cereal and legumes, and one used initially in cereal grinding and, on a later stage, in the processing of a greasy substance. The abrader was found to have been related to hide processing.

The main characteristics of the assemblage from Dikili Tash are the high presence of heavily used tools, the homogeneity in terms of raw material (almost all tools are made of schist) and the existence of morphometric variations. A total of 32 artefacts have been analysed, although the quantitative analytical stage has been delayed for more than half of the samples. The available results permitted the identification of tools used for the processing of cereals and greasy substances.

At Dikili Tash the grinding implements are systematically found in house interiors and present a repetitive close association with thermal/cooking features and storage structures (e.g. House 1). Although the use of grinding implements in outdoor spaces cannot be rejected with absolute certainty, building interiors seem to have formed the primary grinding context in the settlement. Examining specific buildings belonging to the Late Neolithic phases, the rectilinear House 4 of substantial dimensions (11 X 6 m) was partitioned into three equal-sized and non-communicating rooms. Their internal organisation with an oven, a platform and several vessels is similar. Grinding implements have been recovered from all three spaces, but in uneven numbers. Three of them have been subjected to use-wear analysis. The results reveal functional diversity since two tools from the same area (Room A) were reserved for different functions, one for the processing of greasy substances and the other for the processing of cereals in their husked form. The latter, a fragmented and heavily worn handstone with no signs of recent repecking, presents a rather distinct surface morphology with very small but dense plateaus, low rounding of the separate grains and low polish of micropitted type with brighter asperities. This suggests its use for dehusking the grains rather than dehusking and grinding them into flour since the action of grinding would result in more extensive plateaus due to stone against stone friction.

The two neighbouring Kleitos I and Kleitos II settlements have been excavated almost entirely yielding a huge grinding tool assemblage (Chondrou 2018). Based on the data obtained from the use-wear analysis of a very small sample so far, a variety of uses have been established, including the processing of cereal, legumes and greasy substances.

A unique find is a grinding slab with two use-surfaces, one of which is highly concave due to prolonged use. The less worn surface presents use-wear traces indicative of cereal processing. The other surface is ochre-stained with use-wear pointing to hide processing, possibly representing a secondary use of the tool (Fig. 17.11). Ochre is a substance well-known for its hide tanning, colorant and anti-bacterial use from various ethnographic records. Numerous archaeological examples testify to the use of stone implements for the processing of ochre and several cases reveal a connection between ochre and hide-processing (e.g. in flaked industry Audoin and Plisson 1982; Becker 1999; Hayden 2002; in ground stone industry Adams 1988; Bofill and Taha 2013; Dubreuil 2002; Dubreuil and Grosman 2009; González and Ibáñez 2002). In the case of ground stone implements, the archaeological examples include handstones, abraders or polishers, i.e. hand-held, moving upper-active implements. There are two possibilities regarding the use of this implement: a) the tool was first used for ochre grinding (or the direct rubbing of ochre pieces on its surface) and then for hide-processing; b) the tool was used as a passive/stationary work surface for the rubbing of hide in combination with ochre. The abundance and distribution of the ochre over the whole use-surface of the quern suggests that the latter explanation is more plausible. Although the combined use of ochre and hide is well known for handstones, this is, to our knowledge, the first example of a quern combining ochre residues and use-wear related to hide processing. Ochre could have been initially ground (or directly rubbed) on the surface of the quern. Then the hide would have been placed on top of this surface and rubbed with an active tool used in a rectilinear reciprocal stroke in order to absorb the ochre. This action would probably also make the skin softer. The presence of ochre in both the asperities and interstices of the surface microtopography, in some cases accumulating in small cavities (see Logan and Fratt 1993, 423), as well as the extensive, highly reflective sheen could suggest the presence of an additive mixed with the ochre (for a similar observation see also Dubreuil and Grosman 2009, 949).

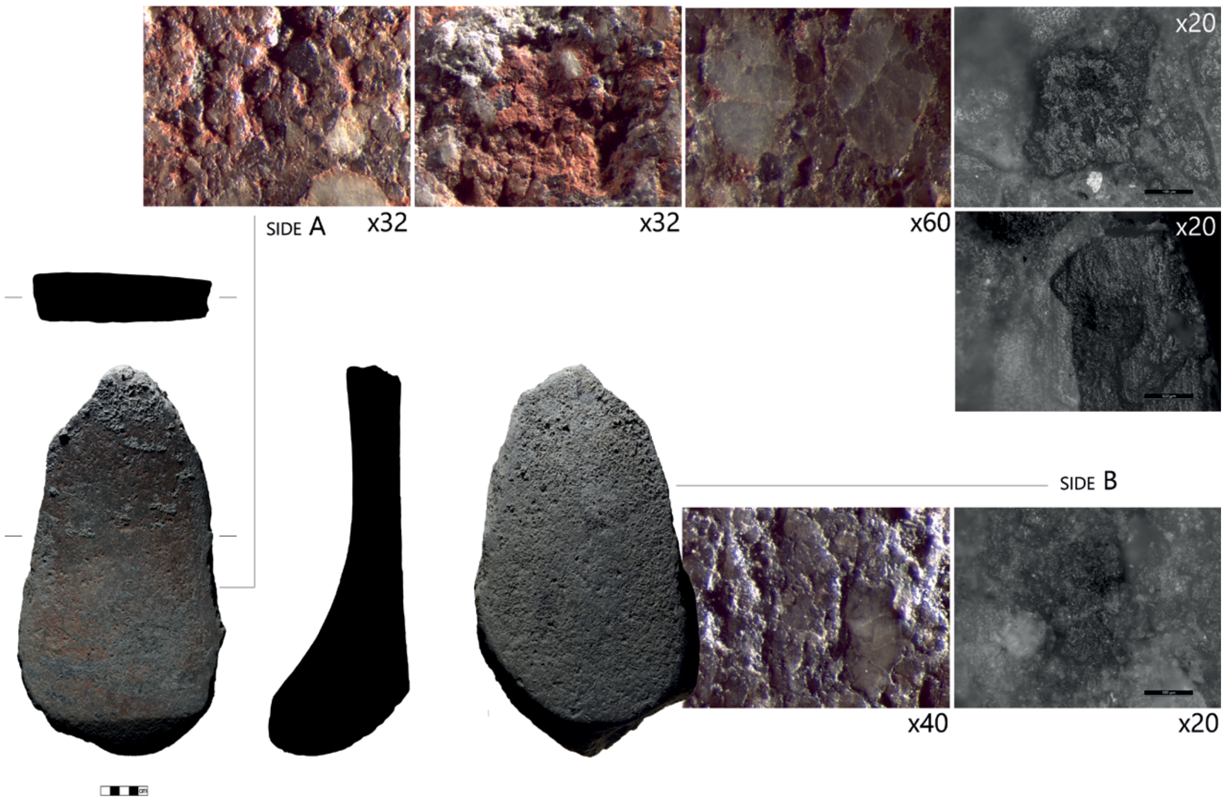


Fig. 17.11 A fragmented grinding slab from Kleitos II with two use-surfaces, one ochre-stained with use-wear pointing to hide processing and one less worn used for cereal processing.

Lastly, three grinding implements recovered from a Middle Bronze Age pit cutting through the Neolithic deposits of Kleitos II have been also analysed. These tools, a quern with a length of over 56 cm and two handstones weighting over 6 kg, the intact one having a length of 39cm, are massive. They are all made of gneiss and bear traces of cereal processing (Fig. 17.7.2a-2d).

Regarding the spatial distribution of the finds, Kleitos grinding tools are found both indoors and outdoors and, as a rule, do not present close spatial association with thermal/cooking facilities. This clearly suggests a different organization of the food-preparation sequences when compared, for example, to Dikili Tash (see also Chondrou 2018; Chondrou and Ziota in prep) or other settlements in the wider Balkan region, where a clustering of activities around thermal structures is detected (see Hodder 1990; Bailey 2000 for various examples). In the case of the remarkably well-preserved first phase of Building 3, the two recovered handstones had different uses. One was related to cereals, the other to pulses, but previously it had also been used for processing cereals.

The rescue excavation of the Early Bronze Age settlement of Ayios Athanasios brought to light the remains of three building sectors. Its grinding assemblage presents 1) a very limited number of worn-out tools, 2) both type 1 and type 2 tools, and 3) high diversity in raw material choices (Chondrou et al in prep). There is quite a variability in the morphometric traits of the handstones, yet their correlation to distinct functional differences was not possible. Our analysis allowed the detection of distinct functional groups, such as tools used for cereal and others for legume processing (Fig. 17.7.4a-4d) as well as some unique cases. For example, a big type 1 handstone was probably initially used for cereal grinding and at some point reused for the processing of hard mineral (Fig. 17.12a). Two other grinding tools have been secondarily used as passive abrasive tools, i.e. as stationary work surfaces for shaping objects, whereas a third one has been associated with hide (Fig. 17.7.6a-6d).

Of special interest is the case of a rather small oval handstone (Fig. 17.12 b). Use-wear analysis revealed distinct evidence of cereal processing, possibly millet (phytolith/starch analysis results were inconclusive). If this is truly the case, this processing tool is valuable indirect evidence for the presence of millet in the settlement and its use for human consumption, since no millet has been identified in the archaeobotanical record of Ayios Athanasios, contrary to other Bronze Age settlements in northern

Fig. 17.12 a A big type 1 handstone from Ayios Athanasios probably initially used for cereal grinding and reused for the processing of hard mineral; b A rather small oval handstone from the same settlement with distinct use-wear that possibly links it to millet processing. Note the sporadic and shallow pecking of its use-surface (i) in contrast to the dense and deep pecking of another tool from the same settlement (ii).

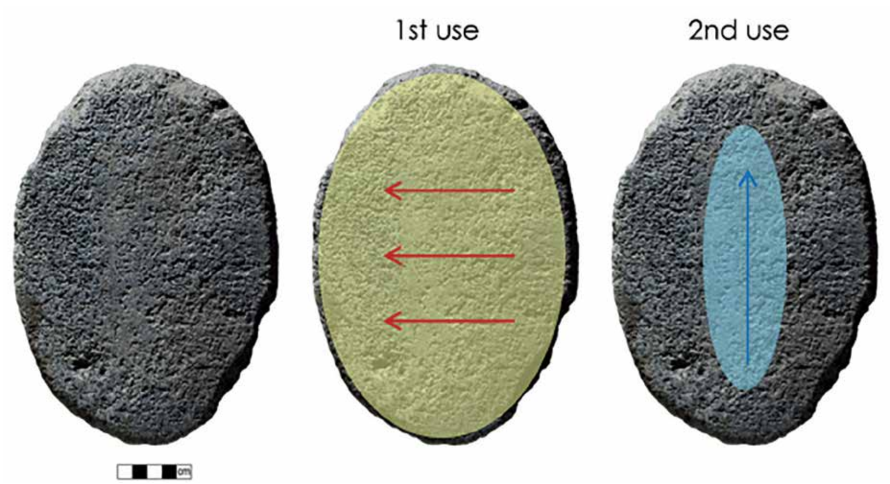


Fig. 17.13 The example of a handstone from Archontiko that has been reused as an abrasive slab for the shaping of artefacts. Note the change that occurs between the two episodes of use in the size of the use-surface and the direction of motion.

Greece (see Valamoti 2017 for an overview of the data). The specific tool also stands out from the assemblage due to its rather "sloppily" pecked use-surface that contrasts the densely pecked and repecked surfaces of almost all the rest of the tools (Fig. 17.12 b, i compared to ii). As we know from ethnographic sources, quite often tools used in the processing of small-sized grains (such as millet itself) bear no pecking at all, therefore this technical peculiarity might very well be use-related (Nixon-Darcus and D'Andrea 2017).

Regarding the spatial distribution of the analysed finds, cereal processing is evident in all three building sectors, same as the tendency for secondary uses of the grinding implements. As far as the context of grinding is concerned, the evidence shows that it was mainly limited to building interiors. Grinding implements found in external areas are few and only in the Eastern Sector do we have a concentration in an open-air area with clay thermal structures (Chondrou et al in prep).

In the tell site of Archontiko the functional analysis revealed a wide range of uses with most of the implements showing evidence of secondary use, often associated with the processing of greasy substances (Fig. 17.7.5a-5d). For example, an intact type 1 handstone (Fig. 17.13) was at some point reused as an abrasive slab for the processing of semi-hard matter (e.g. bone), finally ending up in the interior of a clay thermal structure, either recycled or stored (see also Bekiaris et al 2021). A fragmented type 1 handstone (Fig. 17.14) was initially used for cereal grinding and later reused for the processing of greasy plant matter.

From the ten analysed specimens, nine date back to the Early Bronze Age, with the majority -seven implements- belonging to Phase IV (Early Bronze Age, 2135-1980 cal BC, Papadopoulou 2010), whereas one originates from the Late Bronze Age stratum. From the Phase IV findings, four can be safely attributed to building interiors and the other three very close to their margins. Very few were found to be associated with cereal processing and (almost?) none seem to be in their primary context of use, having been secondarily used or recycled instead (see also Bekiaris et al 2021). The houses of phase IV in Archontiko, full of various household items and stable features, such as pots for cooking, storage or consumption, storage bins, hearths, platforms and ovens (Papadopoulou 2010; Papaefthymiou-Papanthimou and Papadopoulou 2014), and a wide array of (stored?) cereals, such as einkorn, emmer, spelt, free-threshing wheat and barley (Papaefthymiou-Papanthimou et al 2013; Valamoti et al 2008; Valamoti and Petridou this volume), are (almost) empty of tools for cereal grinding. We can assume that the primary grinding context, at least as far as cereals are concerned, was not house interiors (see also Bekiaris et al 2021).

Finally, the Bronze Age site of Angelochori yielded a limited assemblage of grinding implements (Bekiaris et al 2021) from which four items, three originating from building interiors, were selected for functional analysis. They all presented a combination of use-wear traces and micropolishes, with more characteristic the co-presence of the micropitted and deposit type. It seems very plausible that they were initially used for cereal processing and secondarily applied in different activities (i.e. grinding of legumes, oily/greasy substances and hard mineral).

17.5 Discussion

Overall, contrary to past perceptions that prescribed to grinding stone tools a function related to cereal processing exclusively, it is proven that throughout the Neolithic and Bronze Age times these artefacts were used for a variety of activities. Processing of legumes and greasy/oily substances, hide working and mineral grinding should be added to their range of uses.

Cereal processing with grinding implements with flat working surfaces (i.e. querns and handstones) is well illustrated in all of the examined sites. There is

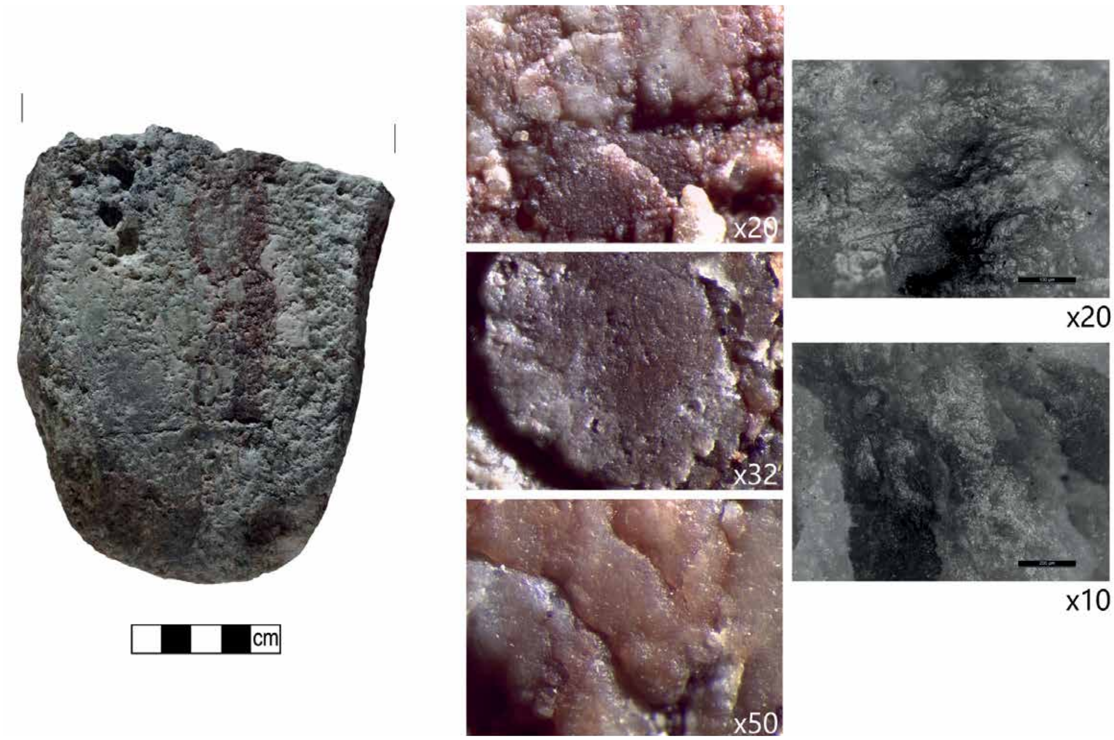


Fig. 17.14 A fragmented type 1 handstone from Archontiko with use-wear that suggests processing of cereal and on a later stage processing of greasy substances. Polish of serrated and micropitted texture is detected in some areas, whereas in others it is covered by a deposit type of polish.

only one exception, the Early Neolithic settlement of Mavropigi-Fillotsairi, whose assemblage is dominated by mortars. The only detected flat-surfaced specimen presents use-wear linked to legume processing. This clear divergence could be an indicator of differences in culinary practices (Ninou et al this volume). Ayios Vlasis, the other early Neolithic settlement in our sample, yielded also a high number of pestles and a few shallow mortars. These tool types are quite rare in the overall Greek Neolithic, which could be signalling diversified traditions of plant exploitation (Ninou et al this volume). In contrast to Mavropigi-Fillotsairi, nevertheless, the small assemblage from Ayios Vlasis contained also a group of querns and handstones that were found to have been associated with cereal processing.

Overall, among the identified cereal processing tools in our sample, there are several cases from Ayios Vlasis, Dikili Tash and Stavroupoli, where the use-wear analysis suggests the processing of cereals in their husked form. Our results, therefore, offer evidence for the diversity of culinary practices even within the same community. The pounding of spikelets in mortars (stone, wooden, or earthen) and the subsequent winnowing and sieving for the removal of the husks and the acquisition of clean seed for grinding is well documented ethnographically. The prevalence of grinding tools with use-wear associated with clean grain processing and the common presence of cereal processing by-products in prehistoric archaeobotanical assemblages from Greece (Valamoti 2010) certify archaeologically the application of this processing sequence. Grinding cereals in their husks, on the other hand, would entail a different process, one which would certainly include sieving, maybe in several successive stages, so that the fragmented husks are removed (Chondrou et al 2021; Procopiou 2003). This would depend on the desired thoroughness and would naturally affect the texture and taste of the end product. The complete refinement of the ground product was not always pursued. The starch and phytolith analysis conducted in pots from the Neolithic Stavroupoli showed that in some cases cereals were intensively cleaned prior to their cooking, in others not (García-Granero et al 2018). Moreover, in the Late Bronze Age site of Akrotiri, Thera, the analysis of “flour” samples revealed their richness in glume phytoliths (Procopiou et al 2002; Sarpaki 1992). On the other hand, these tools with use-wear signatures related to husked cereals might correspond only to the dehusking process and not to the subsequent grinding of the grains. The use of grinding stones for glume wheat dehusking has proven experimentally feasible (Bofill et al 2013), but less efficient compared to pounding with a pestle and mortar (Meurers-Balke and Lüning 1992). This is particularly possible for at least one of the specimens

FUNCTION	Mavropigi-Fyllotsairi	Ayios Vlasis	Stavroupoli	Koroneia	Dikili Tash	Kleitos	Ayios Athanasios	Archontiko	Angelochori
Cereal processing (dehusked)		+	+	+	+	+	+	+	+
Cereal processing (husked)		+	+	+?	+				
Legume processing	+					+	+	+?	+?
Hide/other greasy matter				+	+	+	+	+	+
Mineral processing							+		+
Abrasive stone (as secondary use)							+	+	
Pitted stone (as secondary use)			+						
Other / unidentified							+	+	+

Table 17.2 Types of activities identified through the use-wear analysis of selected grinding specimens.

from Dikili Tash. In that case, it would mean that we have specific implements reserved for specific stages of the cereal processing sequence. There is also a grinding tool from Ayios Vlasis with two use-surfaces that yielded different wear signatures, one related to the processing of husked cereals and the other of dehusked ones. Again, a clear distinction between these activities is suggested, with each use-surface of the same tool being employed for a different stage of cereal processing for food (dehusking and grinding of the grain).

The existence of inter- and intra-site morphometric diversity of the grinding equipment has also been revealed. Although type 1 grinding tools dominate, other tool-types exist as well. It is the functional dimension of this variety that needs further investigation. Although no clear handstone size-function correlation has been observed in our samples like the one detected in Western Europe, where small handstones have been found to be associated with the processing of husked cereals and bigger ones with dehusked cereal grinding (Hamon 2008a, 1517-1518), all tools that yielded use-wear traces associated with the processing of hulled cereal belong to type 1, i.e. the "overhanging type" (Fig. 17.1, A). Also, in the case of Dikili Tash, the generally rare -compared to type 1- type 2 and 3 tools are, according to the optical observations, not associated with cereal processing.

Different strategies of tool manipulation are also clearly attested. Some settlements exhibit an exhaustive use of their grinding equipment (e.g. Early Neolithic Ayios Vlasis, Middle/Late Neolithic Stavroupoli, Late Neolithic Dikili Tash), whereas others feature tools that have not been used until the point of exhaustion (e.g. Late/Final Neolithic Kleitos, Early Bronze Age Ayios Athanasios). Moreover, the distribution of the tools tends to suggest inter-settlement differences regarding the spatial organisation of the grinding activities which are allocated either outdoors or indoors, with or without the thermal structures as their focal point. Some cases suggest the selection of certain implements for specific functions in the context of a single household (e.g. Late Neolithic Dikili Tash) and others hint at possible tool multifunctionality (e.g. Late/Final Neolithic Kleitos II).

The data seem to suggest that the range of functions of grinding tools is amplified through time (Table 17.6), yet the size of our samples does not permit us to support such a claim. What can be said, however, with some certainty is that there is a clear tendency for secondary use and recycling in all three Bronze Age sites of our study, much more generalized than in the Neolithic sites examined. Two of these sites (Ayios Athanasios: Chondrou et al in prep; Archontiko: Bekiaris et al 2021) also present the highest diversity in raw material exploitation for the manufacture of grinding tools. This could actually support the idea of a more "diverse" functional exploitation of the grinding implements. It seems tempting to associate this pattern with the introduction of new species into the range of plants exploited by humans during the Bronze Age era. It is during this period that various plants with seeds rich in oil, such as *Lallemantia* (Lamiaceae), flax/linseed (Linum usitatissimum), gold-of-pleasure (Camelina sativa), and opium poppy (Papaver somniferum) are used offering new ingredients to prehistoric cuisine (Stika and Heiss 2013; Jones and Valamoti 2005; Valamoti 2009, 119-125). On the other hand, it could be an indication of other economic or even social changes that resulted in a more opportunistic use of the available technical means in a broader spectrum of activities.

From a methodological standpoint, our analysis has demonstrated the great potential that the combination of optical observations and quantitative analysis holds for a more detailed understanding of the tools' functions and associated processing activities of the past. Surface measurements with a confocal microscope and characterisation with the method of the continuous wavelet transform permitted the identification of distinct wear signatures, as well as various key factors affecting use-wear formation. Tool raw material variation proved to be one of them: tools made of different rock types but used to process the same material yielded significantly different

SMa results, hinting at the role played by the different tool raw material properties in the evolution of use-wear and, thus, highlighting the necessity of use-wear comparisons between tools of the same raw material. Tools' kinematics proved also to be an important parameter. More case-studies in the future will enhance this methodological package permitting more detailed reconstructions of past activities.

To conclude, this extensive functional analysis of grinding tools from Greek prehistoric sites revealed a mosaic of traditions and trends related to plant consumption and beyond. This study laid the foundations for further research in this region, necessary to gain a clearer insight into past food production and culinary practices.

Appendix

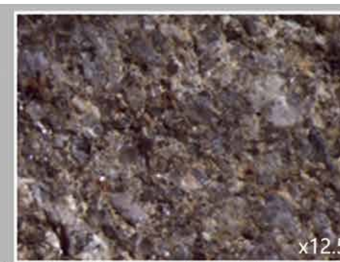
TOOL VARIABLES		
Type of motion	1	Rectilinear
	2	Circular motion
Raw material	1	Sandstone
	2	Andesite
	3	Granite
Size in cm (lower / upper tool)	A1	28 x 20 / 30 x12
	A2	28 x 20 / 14 x 12
	A3	28 x 25 / 12 x 8
	B1	40 x 24 / 36 x 14
	B2	40 x 24 / 14 x 12
	B3	40 x 34 / 12 x 8

Appendix 17.1 The experimental tool variables (Chondrou et al 2021)

Appendix 17.2 List of the conducted experiments and of the plant ingredients used (modified from Bofill et al 2020, 7, Table 2).

Experiment	Ingredient	State / pre-treatment	Processing	Duration	Tool types used	Number of replicas used
E1	Einkorn (*T. monococcum*)	Dehusked	Fine grinding	5 hours	All types	15 grinding pairs
E2.1	Einkorn (*T. monococcum*)	Dehusked	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.1b	Einkorn (*T. monococcum*)	Hulled (untreated)	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.3	Barley (*Hordeum vulgare*)	Hulled (untreated)	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.4	Millet (*Panicum miliaceum*)	Dehusked	Fine grinding	5 hours	Type 2 (A2) – sandstone / Type 3 (A3) – andesite	2 grinding pairs
E2.4b	Millet (*Panicum miliaceum*)	Hulled (untreated)	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.5	Barley (*Hordeum vulgare*)	Malt, commercial	Coarse grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.6	Bitter vetch (*Vicia ervilia*)	Untreated	Splitting	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.6b	Bitter vetch (*Vicia ervilia*)	Split/sieved/winnowed	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.7	Linseed (*Linumusitatissimum*)	Untreated	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.7b	Linseed (*Linumusitatissimum*)	Roasted	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.8	Acorns (*Quercus* sp.)	Dried	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.8b	Acorns (*Quercus* sp.)	Roasted	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.9	Lentils (*Lens culinaris*)	Untreated	Splitting	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.9b	Lentils (*Lens culinaris*)	Split/sieved/winnowed	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.10	Poppy seeds (*Papaver somniferum*)	Untreated	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.10b	Poppy seeds (*Papaver somniferum*)	Roasted	Fine grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E2.11	Spelt (*T. spelta*)	*Grünkern*: Unripe and smoked	Coarse grinding	5 hours	Type 2 (A2) – sandstone	1 grinding pair
E3.1	Einkorn (*T. monococcum*)	De-husked	Fine grinding	10 hours	Type 2 (A2) – sandstone	1 grinding pair
E3.2	Einkorn (*T. monococcum*)	Hulled	Fine grinding	10 hours	Type 2 (A2) – sandstone	1 grinding pair
E3.3	Einkorn (*T. monococcum*)	De-husked	Coarse grinding	10 hours	Type 2 (A2) – sandstone	1 grinding pair
E3.4	Grass Pea (*Lathyrus sativus*)	Untreated	Splitting	10 hours	Type 2 (A2) – sandstone	1 grinding pair
E3.4b	Grass Pea (*Lathyrus sativus*)	Split/sieved/winnowed	Fine grinding	10 hours	Type 2 (A2) – sandstone	1 grinding pair
E4	Barley (*Hordeum vulgare*), millet (*Panicum miliaceum*), Grass Pea (*Lathyrus sativus*), acorns (*Quercus* sp.)	Hulled barley, de-husked millet, split/sieved/winnowed grass pea, roasted acorns	Fine grinding	8 hours	Type 2 (A2) – sandstone	1 grinding pair

Grinding dehusked einkorn



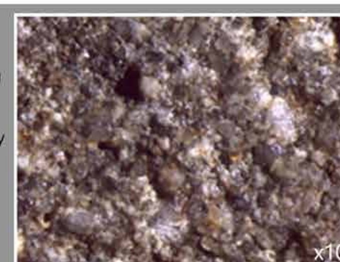
Observations after 3 hours of use

Use-wear traces: Single grains present rounding and levelling of the summits on the high topography. There is no visible macroscopic polish. Few short striations have developed over the big crystals in the case of the sandstone tools, but none on the andesitic ones. **Distribution of use-wear:** Loosely distributed levelled areas. Pits from the pecking process remain all over the surface. Edge rounding has started to appear in the lower topography, but is not very developed. **Morphology of topography:** The levelled areas have a sinuous/rounded cross-section morphology and medium roughness.

Observations after 5 hours of use

Use-wear traces: Grain removal and rounding on the high topography. Low macroscopic polish on the central area of the use-surface. Striations on bigger inclusions. **Distribution of use-wear:** Formation of major plateaus in the centre of the use-surface, where previous traces of pecking have been worn out through grinding (stone against stone abrasion). These plateaus alternate with pecked areas less affected by grinding, especially on the lateral sides of the use-surfaces. Only some low degree of grain levelling is detected in low topography. **Morphology of topography:** Flat and sinuous plateaus in type 1 and 2 tools, more rounded morphology in type 3 tools.

Grinding husked einkorn and barley



Observations after 3 hours of use

Use-wear traces: Single grains on the highest zones of the surface present microfracturing and some rounding of their summits but no levelling. Few linear traces are found concentrated in the areas with the highest abrasive wear. There is no macroscopic polish but grains appear slightly more shiny compared to earlier stages of use. **Distribution of use-wear:** The pecked surface has been preserved. The low topography remains unaltered. Only the highest asperities have developed levelling of a rough texture. Grains preserve clear margins in these areas. **Morphology of topography:** Intense stone against stone abrasion between the quern and the handstone has created small levelled areas concentrated in certain parts of the use-surface. In the central zone of the surface, the uneven topography is preserved due to the presence of husks during grinding.

Observations after 5 hours of use

Use-wear traces: Low grain rounding. Low polish on the summit of individual grains (due to the presence of silica in the processed husks). Microfractures preserved form the manufacturing sequence. Absence of linear traces. **Distribution of use-wear:** The pecked surfaces from the initial manufacturing process are preserved to some extent after the grinding. Some rough levelling is detected in areas where the contact between handstone and quern was more intense (i.e. central area). The low topography remains almost unaltered. **Morphology of topography:** Sinuous plateaus and grains with angular edges.

Grinding millet

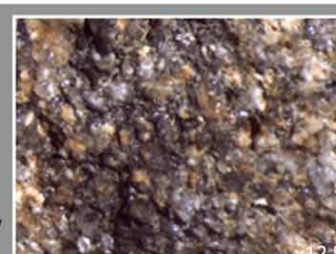
Observations after 3 hours of use

Use-wear traces: Dark coloration macroscopically visible. Short striations on separate crystals. Some rounding of the grains. **Distribution of use-wear:** The central, more irregular zone of the surface presents dark coloration. In the same area, grains in the high topography present some rounding of their summits. **Morphology of topography:** The central zone of the surface is rough, with small levelled areas with sharp irregular limits. The lateral parts of the surface are more levelled due to higher stone against stone abrasion.

Observations after 5 hours of use

Use-wear traces: Dark coloration in macroscopic view seen as polish under magnification. Grain borders are highly diffused. Linear traces appear in the form of pecking pits alignment and small, short striations on the bigger crystals. **Distribution of use-wear:** A homogeneous rough surface has been generated by the abrasion. Extensive platforms with dark coloration have formed in the periphery of the irregular central zone of the surface without extending to its margins. The dark coloration is visible on the levelled areas as well as on individual big crystals. **Morphology of topography:** Rounded morphology of plateaus in tool type 3, flat with sharp limits in types 1 and 2. Grain rounding in low topography and intermediate zone, observed in hulled millet processing as well.

Grinding acorns



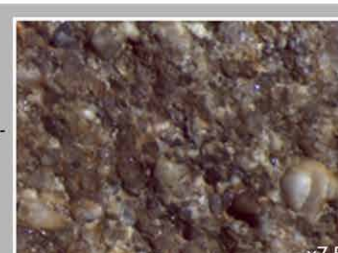
Observations after 3 hours of use

Use-wear traces: Microfractures and grain removal due to the action of pounding (for the crushing of acorns prior to their grinding) and some grain rounding. No visible linear traces, no polish. **Distribution of use-wear:** In the high topography, grains present some rounding of their summits. The low topography is irregular. **Morphology of topography:** The overall surface has a very rough topography due to pecking and pounding. The edges of the grains are sharp, except for low rounding in high topography.

Observations after 5 hours of use

Use-wear traces: Grain rounding, but not total levelling of the plateaus. Some striations produced by grain removal and microfractures. Low polish in the microscopic scale, especially in the intermediate zone between low and high topography. **Distribution of use-wear:** The processing of roasted acorns caused more intense use-wear patterns, such as more extended smooth areas and a darker, matte coloration, compared to dried acorns. The pounding strokes to crush the nuts maintained the rough, pecked area in the centre of the active surface. **Morphology of topography:** The plateaus have angular edges. No alterations in low topography.

Grinding legumes



Observations after 3 hours of use

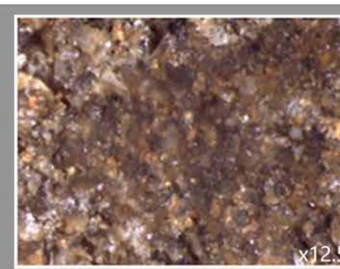
Use-wear traces: Small levelled plateaus of rough texture, due to microfracturing and grain removal. No visible linear traces, no polish. **Distribution of use-wear:** The levelled plateaus are loosely distributed over the surface of the quern. On the handstone, an alignment of pecking pits is observed parallel to the axis of motion. **Morphology of topography:** The overall surface is homogeneous rough. The plateaus have a sinuous/flat cross-section morphology. The low topography is irregular, the grain edges are angular.

Observations after 5 hours of use

Use-wear traces: General grain rounding. Levelled areas are created through the rounding and levelling of grain summits. Separate grain borders are well defined. Few short striations are detected on bigger crystals. No polish. Microfractures and grain removal from the manufacture still remain visible. **Distribution of use-wear:** Levelled areas are loose over the whole surface topography, except the central zone, where levelling is denser. **Morphology of topography:** Sinuous texture and rounded morphology. The low topography is almost unaltered, with angular edges in general, and only some grain levelling in the centre. The handstone surface exhibited more levelling.

Appendix 17.3 Macroscopic and low magnification characteristics of use-wear observed on the experimental grinding tools (based on Bofill et al 2020, 18-19, Table 4).

Grinding oily seeds (linseed, poppy seed)



Observations after 3 hours of use

Use-wear traces: Dark coloration of the surface, extensive levelled plateaus, rounding of the grains and levelling of their summits. Thin and dense linear traces detected on high topography. **Distribution of use-wear:** Rounding of grains in both low and high topography. Polish more visible in the intermediate zone, on the ridges of the plateaus and protruding grains. **Morphology of topography:** Flat and smooth plateaus with a deposit type of polish that affects the low topography as well.

Observations after 5 hours of use

Use-wear traces: A sticky appearance and a "deposit" dome polish, especially over grey crystal grains of sandstone surfaces. Polish affects the topographic asperities and the intermediate zone. Grain borders are diffused. No significant difference detected between the polish caused by the processing of linseed and poppy seeds. **Distribution of use-wear:** Macroscopically, the development of use-wear is more pronounced (in terms of i ntensity and extent) compared to other experiments. **Morphology of topography:** Roasted linseed produced more pronounced coloration but less extended levelled areas compared to untreated linseed. Smooth and flat platforms.

Coarse grinding of malt and grünkern

Observations after 3 hours of use

Use-wear traces: Grain removal, very low rounding of grains, no linear traces, no polish. **Distribution of use-wear:** The central zone of the surface is more irregular. In the same zone, grains in the high topography present some low rounding of their summits. M**orphology of topography:** Overall the surface is irregular and rough. Individual grains present microfracturing but also some low degree of rounding. The low topography remains unaltered.

Observations after 5 hours of use

Use-wear traces: Levelling of the grain summits only. Grain rounding on querns and plateaus with sharper edges on handstones. No linear traces and no polish. **Distribution of use-wear:** Very low development of use-wear. Some loosely distributed levelled areas caused by stone against stone contact. **Morphology of topography:** Sinuous platforms with rough texture. The low topography is almost unaltered.

Appendix 17.3 continued.

Appendix 17.4 (following page) List of analysed artefacts (catalogue number, provenance, type and subtype, preservation, number of use-surfaces, raw material and functional hypothesis). In cases of secondarily used and reshaped artefacts, the state and percentage of preservation regarding their initial form are given in brackets. Note: only implements for which all stages of analysis have been completed are included.

Artefact number	Site of provenance	Tool type	Sub-type based on kinetics	State of preservation	Percentage of initial tool preserved	Number of use-surfaces	Raw material	Functional hypothesis based on use-wear
1247-1630	Ayios Vlasis	quern	Type 1	whole		1	basalt	cereal processing
1296	Ayios Vlasis	quern	Type 2	intact		1	sandstone	cereal processing (with different previous use?)
1587	Ayios Vlasis	handstone	Type 1	fragmentary	>3/4	1	basalt	cereal processing
1284	Ayios Vlasis	handstone	Type 1	fragmentary	<1/2	2	basalt	side A: cereal processing / side B: husked cereal processing
1248	Ayios Vlasis	handstone?	Type 1	fragmentary	<1/4	2	sandstone	cereal processing
1633	Ayios Vlasis	handstone?	Type 1	fragmentary	<1/4	2	greenschist	side A: husked cereal processing / side B: cereal processing
1632	Ayios Vlasis	side A: quern / side B: handstone?	Type 2	fragmentary	<1/2	2	basalt	cereal processing
FGS 203	Mavropigi-Fillotsairi	handstone	Type 1	intact		1	sandstone	legume processing
36	Stavroupoli	handstone reused possibly as anvil	Type 1	Intact / [fragmentary]	[>2/3]	1	gneiss	cereal processing
219	Stavroupoli	quern	Type 3	fragmentary	>3/4	1	gneiss	cereal processing
224	Stavroupoli	handstone	Type 1	fragmentary	>3/4	1	greenschist	husked cereal processing
285	Stavroupoli	quern	Type 1 or 2	fragmentary	<1/2	1	greenschist	husked cereal processing
310	Stavroupoli	handstone	Type1	fragmentary	>1/2	1	gneiss	cereal processing
360	Stavroupoli	quern	Type 3	fragmentary	<1/2	1	gneiss	cereal processing
496	Stavroupoli	handstone	Type 1	fragmentary	<1/2	1	greenschist	cereal processing
526	Stavroupoli	handstone	Type 1	fragmentary	<1/2	1	gneiss	husked cereal processing
VIp.17	Stavroupoli	handstone	Type 1	fragmentary	<1/2	1	greenschist	cereal processing
16	Kleitos	handstone	Type 1	fragmentary	3/4	1	gneiss	legume processing (1st use: cereal)
24	Kleitos	handstone	Type 1	fragmentary	≤1/2	1	gneiss	cereal processing (combined with something else?)
57	Kleitos	handstone	Type 1	fragmentary	≤1/2	1	gneiss	cereal processing
131	Kleitos	quern	Type 1	almost intact		2	sandstone	side A: hide + ochre / side B: cereal processing
I17_#5_A	Kleitos	quern	Type 1	intact		1	gneiss	cereal processing
I17_#5_B	Kleitos	handstone	Type 1	almost intact		1	gneiss	cereal processing
I17_#5_125	Kleitos	handstone	Type 1	intact		1	gneiss	cereal processing
538	Koroneia	handstone	Type 1	fragmentary		1	gneiss	husked cereal processing
544	Koroneia	handstone		fragmentary	>1/2	1	gneiss	hide processing
739	Koroneia	handstone	Type 2	intact		2	gneiss	side A: cereal processing / side B: cereal processing (with different previous use?)
860	Koroneia	quern	Type 1	fragmentary	≥2/3	1	gneiss	1st use: cereal processing / 2nd use: something greasy?
883	Koroneia	quern	Type 1	fragmentary	~2/3	1	gneiss	cereal processing
1018	Koroneia	handstone	Type 1	almost intact		1	gneiss?	cereal processing
6336-003	Dikili Tash	handstone	Type 1	fragmentary	>1/2	1	schist	husked cereal processing
6336-004	Dikili Tash	handstone	Type 1	almost intact		1	schist	cereal processing
6339-004	Dikili Tash	quern	Type 1	fragmentary	≤1/2	1	schist	cereal processing
6168-001	Dikili Tash	handstone	Type 1	fragmentary	>1/2	1	schist	cereal processing
6182-002	Dikili Tash	quern?	Type 1	almost complete		2	schist	indeterminable due to preservation factors
61181001	Dikili Tash	handstone	Type 2	fragmentary	<1/4	1	schist	processing of greasy matter
61182001	Dikili Tash	handstone	Type 1	fragmentary	<1/2	1	schist	husked cereal processing
30210432-04	Dikili Tash	quern	Type 1	almost complete		1	schist	cereal processing
30210432-011	Dikili Tash	handstone?	Type 1	complete		1	schist	indeterminable due to preservation factors

Artefact number	Site of provenance	Tool type	Sub-type based on kinetics	State of preservation	Percentage of initial tool preserved	Number of use-surfaces	Raw material	Functional hypothesis based on use-wear
29910642-008	Dikili Tash	quern	Type 1	fragmentary	>1/2	1	schist	husked cereal processing
SectV_prov. p.	Dikili Tash	quern	Type 1	fragmentary	>3/4	1	schist	processing of greasy matter
226	Ayios Athanasios	quern	Type 1	fragmentary	<1/2	1	sandstone	1st use: cereal processing / 2nd use: processing of greasy matter
316	Ayios Athanasios	quern	Type 2	fragmentary	<1/2	1	gneiss	cereal processing
331	Ayios Athanasios	quern	Type 2	fragmentary	<1/2	1	dunite	cereal processing
397	Ayios Athanasios	quern	Type 1	fragmentary	<1/2	1	gneiss	cereal processing
425	Ayios Athanasios	handstone	Type 1	fragmentary	>1/2	1	conglomerate	cereal processing
427	Ayios Athanasios	handstone	Type 1	fragmentary	>3/4	1	gneiss	legume processing
429	Ayios Athanasios	handstone	Type 1	almost intact		1	amphibolite	millet? processing
458-509-510	Ayios Athanasios	handstone	Type 1	whole		1	conglomerate	1st use: cereal-processing / 2nd use: unidentified matter
501	Ayios Athanasios	quern	Type 1	fragmentary	<1/2	1	greenschist	cereal processing
551	Ayios Athanasios	quern	Type 1 or 2	intact / [fragmentary]	[<1/2]	1	gneiss	1st use: processing of greasy matter? / 2nd use: abrasive slab
566	Ayios Athanasios	quern	Type 1	fragmentary	<1/2	1	gneiss	cereal processing
567	Ayios Athanasios	handstone	Type 1	almost intact		1	sandstone	cereal processing
570	Ayios Athanasios	quern	Type 1	fragmentary	<1/2	1	gneiss	processing of greasy matter (with possibly different previous use)
572	Ayios Athanasios	handstone	Type 1	intact		1	conglomerate	1st use: cereal processing ? / 2nd use: hard mineral processing
589	Ayios Athanasios	quern	Type 1	fragmentary	>3/4	1	gneiss	cereal processing
595	Ayios Athanasios	handstone	Type 2	fragmentary	>2/3	1	conglomerate	indeterminable due to preservation factors
1	Archontiko	quern	Type 1	fragmentary	>1/2	1	gneiss	1st use: cereal processing / 2nd use: unidentified matter (possibly a short term episode)
12	Archontiko	handstone	Type 1	fragmentary	≥2/3	1	granite	processing of greasy matter
19	Archontiko	handstone	Type 1	intact		initially 1 (2 related to its 2ndary use)	gneiss	1st use: processing of greasy matter / 2nd use: abrasive slab
33	Archontiko	handstone	Type 1	fragmentary	<1/2	1	sandstone	1st use: cereal processing / 2nd use: something greasy? (possibly a short term episode)
34	Archontiko	quern	Type 2?	almost intact		1	granite	processing of greasy matter?
36	Archontiko	handstone	Type 2?	intact / [fragmentary]	[>1/2]	1	sandstone	1st use: cereal processing / 2nd use: processing of greasy matter
37	Archontiko	handstone	Type 1	fragmentary	>1/2	1	gneiss	legume processing?
37 s.C	Archontiko	handstone	Type 1	fragmentary	<1/2	2	granite	1st use: cereal processing / 2nd use: processing of greasy matter
57	Archontiko	handstone	Type 2	fragmentary	<1/2	1	conglomerate	processing of greasy matter
78	Archontiko	quern	Type 1?	fragmentary	<1/6	at least 1	ophiolitic group (maybe dunite)	1st use: cereal processing / 2nd use: processing of greasy matter
3	Angelochori	handstone	Type 1	almost intact		1	granite	1st use: cereal processing / 2nd use: hard mineral
6	Angelochori	handstone	Type 1	fragmentary	≤1/2	1	sandstone	1st use: cereal processing / 2nd use: processing of greasy matter
9	Angelochori	quern	Type 1	fragmentary	>3/4	1	sandstone	1st use: cereal processing / 2nd use: legume processing?
16	Angelochori	handstone	Type 1	intact		1	granite	1st use: cereal processing / 2nd use: processing of greasy matter?

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Chapter 18

The daily grind. Investigating the contexts of food grinding practices and tools in the Neolithic of southeastern Europe

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Abstract

This paper examines the spatial contexts in which the consumption of the food grinding macrolithic equipment (grinding slabs and handstones, mortars and pestles) occurs throughout the Neolithic of Southeastern Europe. The aim is to investigate how grinding technology was organized and practiced at different settlements, within a variety of activity areas such as houses, open spaces, pits and ditches. Our goal is to investigate similarities, differences and spatiotemporal variability and/or change as regards the contexts of grinding. The spatial arrangement of grinding tools and associated practices allows us to approach aspects of Neolithic socioeconomic organisation and symbolic expression in our study area.

Keywords: *Neolithic Greece, Neolithic Balkans, grinding tools, grinding slabs, handstones, food-processing equipment*

18.1 Introduction

Archaeological research on neolithic grinding implements, usually assigned to the broader group of ground stone or macrolithic artifacts, has come through a long and twisted road to form its current methodological and interpretive profile. Overcoming the negligence and indifference for the specialized study of such artifacts, usually perceived as mundane finds of a "predominantly utilitarian character" (cf. Perlès 1992, 143), and thus presented in many publications only briefly, through short descriptive catalogs and inventory lists (see Bekiaris et al 2020 for a relevant discussion for prehistoric Greece), they were progressively recognized as significant elements of the "Neolithic package". Discussions concerning their key-role in the emergence of agricultural subsistence strategies (cf. Hodder 2017) and their varied economic, social and symbolic meaning (e.g. Lidström-Holmberg 1998; Van Gijn 2014; Watts 2014) are dominant in the literature.

Over the last two decades, innovative methodological protocols and analytical techniques have been applied to the study of grinding tools. Site-related, holistic macroscopic studies (e.g. Baysal and Wright 2005; Bekiaris 2018; Chondrou 2018, 2020; Tsoraki 2008; Stroulia 2010, 2018; Wright et al 2013), use-wear analyses (e.g. Adams 1988,

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2013; Bofill 2012; Bofill et al 2014; Cristiani and Dalmeri 2011; Dubreuil 2002, 2008; Dubreuil and Grosman 2013; Hamon and Plisson 2008; Van Gijn and Verbaas 2009), microbotanical analyses (Buonasera 2013; Fullagar et al 2008; Liu 2015; Liu et al 2010; Piperno et al 2009; Portillo et al 2013; Santiago-Marrero et al 2021), experimental approaches (e.g. Bofill et al 2020; Chondrou et al 2018; Stroulia et al 2017), contextual and micro-regional studies (e.g. Bekiaris 2020; Tsoraki 2007; Chondrou 2022) or synthetic overviews of a diachronic perspective (e.g. Bekiaris et al 2020; Wright 2000), have resulted to more diverse and complex narratives about the life-histories of the grinding implements and shed new light on their integral role for the societies of the past.

Several scholars worldwide have connected grinding tools with the domestic sphere and the concept of the household. Ian Hodder, for instance, sees the grinding of plant foods as a productive, possibly gender orientated, activity that was associated with oven areas within the house in the Neolithic of southeastern Europe (Hodder 1990, 65). According to Katherine Wright, several practices, such as the manufacture, consumption, storage and abandonment of grinding stones had occurred mostly within houses in neolithic Çatalhöyük (Wright et al 2013) and some households may have shared their grinding equipment (Wright 2014). Furthermore, Christina Tsoraki argues that grinding implements at Çatalhöyük held a vital role in the lives of houses and their occupants since they were associated with practices and acts (e.g. subsistence, productive activities, curation, deposition, ritual) that defined both everyday life and significant events in the histories of the houses and their occupants (Tsoraki 2018). In Northern and Western Europe, deposits/hoards of grinding tools, often placed in a structured way within pits or other cut-features (e.g. postholes, cooking pits) have been associated with houses and the domestic environment (Hamon 2008; Graefe et al 2009; Hamon 2020). According to Caroline Hamon, these hoards may have held a symbolic value, by forming a conceptual link between the deposited grindstones and the agricultural economy (cf. Hamon 2008), while they may also reflect other aspects of neolithic society, such as social status, the ancestral past, commemorative acts (cf. Hamon 2020). In Britain, Alistair Barclay and Philippa Bradley (2017) consider the presence of querns within neolithic burials, as a symbolic act of bringing elements of the house and the domestic arena into the grave, either to link or separate the realms of the dead and the living. It is rather evident that all the above cases focus on the close association of grinding practices with the settlement, the house and the domestic sphere while stressing their importance for neolithic life, the socioeconomic and ideological reproduction of neolithic communities.

This paper explores these issues in the context of the Greek[1] and Balkan Neolithic (Fig. 18.1), by examining the neolithic grinding implements (Tables 18.1 and 18.2): the grinding slabs (or querns) and their active counterparts, the handstones (or handheld grinders). Focusing on the spatial contexts, associated with the consumption and deposition of the neolithic grinding equipment, we investigate how grinding practices were organized and performed by the neolithic communities of Greece and the Balkans within different social contexts (e.g. in private houses or communal areas). Furthermore, we explore the association of grinding practices with a diverse array of other daily tasks and events, such as cooking, storage, burial and ritual acts. We argue that grinding equipment formed a vital material component of the neolithic household, closely associated with the economic and social expression of the neolithic societies of Greece and the Balkans. Besides the grinding implements, which constitute the core of this study, references to another pair of neolithic food-processing stone implements, pounding stone tools, specifically mortars and pestles, are also made in the text. In this case, however, the archaeological data are rather limited since mortars and pestles are rarely encountered in the neolithic of Greece and the Balkans (cf. Bekiaris et al 2020). Therefore, only the most prominent cases -in terms of contextual integrity- are discussed in this paper.

Over the past five years, a broad, multileveled research regarding the macrolithic food-processing tools of prehistoric Aegean and the Balkans was conducted in the context of the ERC Project PlantCult[2] (cf. Bekiaris et al 2020; Valamoti et al 2017, 2020; Chondrou et al this volume). Among the project's objectives was a thorough literature review of these tools, placing emphasis on technological aspects and spatial contextual associations of the grinding and pounding toolkits of prehistoric Greece (see Bekiaris et al 2020) and the Balkans. An analytical tool, the Archaeogrinding Database, was thus created by the project to organize and manage the published data, and combine it with the data deriving from the study of unpublished assemblages that were also studied in the context of ERC Project PlantCult. This paper is based on this data.

1 Regarding Greece, it should be noted that the vast majority of the data discussed in this article derive from sites located in Northern Greece, especially the region of Macedonia. The case studies from the southern parts of the country and the Aegean Islands are significantly fewer. This imbalance reflects the state of research at different parts of Greece (also discussed in Bekiaris et al 2020).

2 Project PLANTCULT (Valamoti et al 2017) is funded by the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Program (Consolidator Grant, Grant Agreement No 682529). For more information, visit: plantcult.web.auth.gr

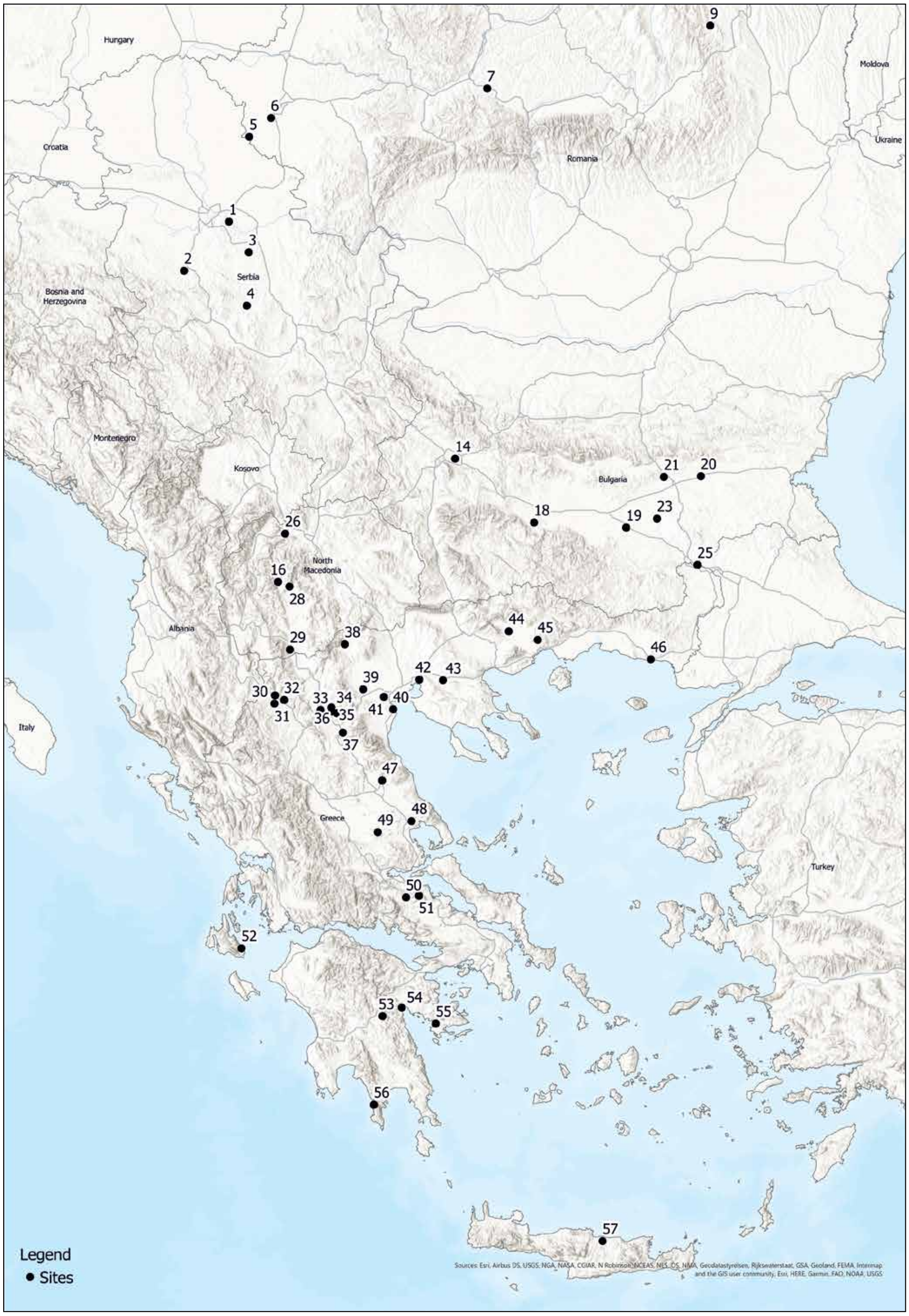

Fig. 18.1 Map with the Neolithic sites mentioned in the text: 1. Vinca, 2. Stubline, 3. Selevac, 4. Divostin, 5. Foeni Salas, 6.Parta, 7. Miercurea Sibiului-Petris, 8. Traian, 9. Vermesti, 10. Mangalia, 11. Medgidia, 12. Podgoritsa, 13. Oussoe, 14. Slatina Sofia, 15. Cavdar, 16. Balgarchevo, 17. Kalogerovo, 18. Kapitan Dimitievo, 19. Yabalkovo, 20. Hadzhidimitrovo, 21. Karanovo, 22. Sarnevo, 23. Simeonovgrad, 24. Luybimets, 25. Kapitan Andreevo, 26. Tumba Madjari, 27. Govrlevo, 28. Zelenikovo, 29. Porodin, 30. Koromilia, 31. Avgi, 32. Dispilio, 33. Mavropigi-Fillotsairi, 34. Kleitos, 35. Megalo Nisi Galanis, 36. Toumba Kremastis Koiladas, 37. Servia, 38. Sossandra, 39. Nea Nikomedeia, 40. Makriyalos, 41. Paliambela, 42. Stavroupoli, 43. Koroneia, 44. Sitagroi, 45. Dikili Tash, 46. Makri, 47. Rachmani, 48. Sesklo, 49. Achilleio, 50. Elateia, 51. Ayios Vlasis, 52.Drakaina Cave, 53. Ayioryitika, 54. Lerna, 55. Franchthi Cave, 56. Alepotrypa Cave, 57. Knossos.

Greek Sites	Chronology	House/Building	Open space	Pit	Ditch	Burial	Recycling in a new context	Reference
Achilleion	EN	GE	GE, deliberately broken querns, ceremony/ritual?	GE, deliberately broken querns, ceremony/ritual?				Gimbutas et al 1989
Ayios Vlasis	EN	GE	GE, PE, Notably large number of both preforms and finished pestles					Chondrou pers. observ.
Mavropigi-Fillotsairi	EN	PE. A single grinding tool in the interior of central pit house						Ninou et al this volume
Nea Nikomedeia	EN	GE						Pyke 1993
Sossandra	EN	GE, Notably large number of grinding tools in house interior						Georgiadou 2015
Elateia	EN/MN	GE, PE		GE, PE				Weinberg 1962
Paliambela	EN/MN	GE, PE, PI. Mortars fixed in the floors of some MN houses.	PE, Mortars carved on the bedrock at an EN open area					Siamidou 2017; Tsartsidou and Kotsakis 2020
Sesklo	EN/MN	GE						Wijnen 1981; Souvatzi 2008
Knossos	EN/LN	GE, PE					GE Incorporated into foundations of walls or within other structures	Evans 1964
Franchthi cave	EN-FN						GE Incorporated in thermal structure	Stroulia 2010
Lerna	MN	GI, GE	GE					Banks 2015
Stavroupoli	MN	GE, GI in vicinity to hearth	GE					Alisøy 2002; Kotsos 2013, 2018
Avgi	MN/LN	GE associated with small concentrations of processed agricultural products and pots	GE. Varied spatial patterns in the relation of GE and cooking facilities	GE. Possible ritual practices, structured deposits, refuse disposal	GE			Bekiaris 2018, 2020
Servia	MN/LN	GE, PE, Frequent association to hearths	GE in close association to houses/yards				GE Packing postholes	Mould et al 2000
Ayioryitika	MN-FN					GE		Petrakis 2002, 57
Dikili Tash	LN	GE	GE	GE			GE incorporated into the sub-structure of a clay platform	Chondrou pers. observ.
Dispilio	LN	GE in vicinity to cooking facilities	GE					Kalogiropoulou 2013; Bekiaris pers. observ.
Drakaina Cave	LN						GE as delinea-tion of hearth	Bekiaris pers. observ.
Koromilia	LN		GE	GE				Bekiaris pers. observ.
Koroneia	LN			GE, PE			GE Incorporated in thermal structure	Almasidou 2019
Makri	LN	GE	GE			GE		Bekiaris 2007
Makriyalos	LN	GE, PE	GE, PE	GE. Deliberately broken, evidence for a feasting event.	GE, PE			Tsoraki 2008
Rakhmani	LN	GE						Wace and Thompson 1912
Toumba Kremastis Koiladas	LN			GE burned or deliberately broken				Chondrou 2011; Stroulia and Chondrou 2013
Alepotrypa Cave	LN/FN					GE		Stroulia 2018
Kleitos	LN/FN	GE, PE	GI, GE, PE Hardly ever associated to cooking facilities	GE	GE, PE		GE Incorporated in thermal structure	Chondrou 2018, 2020

Tables 18.1 (above) and 18.2 (right) Neolithic sites in Greece and the Balkans mentioned in the text, with information regarding the occurrence of stone grinding equipment (GE), pounding equipment (PE) and grinding installations (GI) within different spatial contexts. Short descriptions of the exact find spots, co-related finds, state of preservation and context interpretation are provided. Relevant chronology and bibliographic references are also noted.

Balkan Sites	Chronology	House/Building	Open space	Pit	Ditch	Burial	Recycling in a new context	Reference
Foeni-Salaş	EN	PE						Greenfield and Draşovean 1994
Miercurea Sibiului-Petriş	EN			GE. Ritual pit				Luca et al 2009
Slatina Sofia	EN	GE in vicinity to oven						Nikolov 1989
Yabalkovo	EN	GE. PE permanently fixed on the floors.						Leshtakov et al 2007
Čavdar	EN/MN	GI in vicinity to ovens						Georgiev 1981
Karanovo	EN-MN	GE, PE						Höglinger 1997
Cerje-Govrlevo	MN	GI in vicinity to ovens						Fidanoski 2015
Tumba Madžari	MN	GE						Kotsos 2018
Parta	MN/LN	GE Hand mill fixed in the outside wall of a "shrine"						Lazarovici et al 2002
Divostin	LN	GE						Bogdanovic 1988
Hadzhidimitrovo	LN			GE. Ritual pit				Nikolov 2011
Kalugerovo	LN			GE. Ritual pit				Nikolov 2011
Kapitan Andreevo	LN			GE. Ritual pit				Nikolov 2015
Kapitan Dimitrievo	LN	GE						Nikolov 2000
Luybimets	LN			GE. Ritual pit				Nikolov 2011
Mangalia	LN					GE		Volshi and Irimia 1968
Medgidia	LN	GE, GI associated to storage vessels						Marinescu-Bîlcu 2000
Oussoe	LN			GE. Ritual pit				Nikolov 2011
Podgoritsa	LN			GE. Ritual pit				Nikolov 2011
Porodin	LN		GE					Grbić 1960; Kotsos 2017
Sarnevo	LN			GE. Ritual pit				Nikolov 2011
Selevac	LN	GE	GE				GE, buried under house floors	Spears 1989
Simeonovgrad	LN			GE. Ritual pit				Nikolov 2011
Stubline	LN	GI						Crnobrnja 2012; Spasić and Živanović 2015
Traian	LN					GE		Chapman 2000
Vermeşti	LN						GE, buried under house floor	Chapman 2000
Vinca	LN	GE in vicinity to oven						Antonovic 2008
Zelenikovo	LN	GE						Stojanova-Kazurova and Rujak 2016

18.2 The materials under study

Neolithic food-processing equipment includes two basic sets of ground stone or macrolithic tools: *grinding slabs* and *grinders*, *mortars* and *pestles*. The former set was usually employed for grinding substances and materials into smaller particles. The latter was used to pulverize and reduce materials through pounding or crushing or mixing them through stirring (cf. Adams 2002, 98-150). Among other tasks (e.g. the processing of minerals, pigments, salt and clay, the grinding of bark and roots and the shaping of several objects), both pairs are associated with the processing of plant foods, including the dehusking of hulled cereals, the splitting of pulses, the coarse grinding of parboiled grain for bulgur making, the finer grinding of grain for the production of flour and the processing of wild seeds, fruits and nuts (see some examples in Adams 2002; Runnels 1981; Wright 1992).

Grinding toolsets consist of a lower, passive implement, the *grinding slab* or *quern*, that receives the substance to be processed and remains static during use. The upper, active component, the *grinder* or *handstone*, moves over the lower stone surface and the processed substance. Both tool-types operate more efficiently and maximize their functional potential when their contact surfaces (the workfaces) are compatible in configuration (i.e. flat grinding slabs and grinders, concave grinding slabs with convex grinders, etc), thus achieving an optimal fit between them (cf. Delgado-Raack and Risch 2009, 6).

Based on the current archaeological evidence, the neolithic communities of Greece (cf. Bekiaris et al 2020, 142-144; Chondrou 2020, 289, 294) and the Balkans must have used the following grinding pairs[3] (Fig. 18.2): 1. grinding slabs with "open", unrestricted workfaces (Fig. 18.3a) in combination with a handstone whose length overlaps (Fig 18.4b) the width of the lower implement. The active component moves at a reciprocal, back-and-forth motion over the passive implement, while its manipulation requires the use of both hands, which are placed either on the two protruding ends of the handstone or on its back (corresponding with Type B in Bekiaris et al 2020). In some, but not all cases, the handstone could have acted in an "overhanging" manner (cf. Hamon 2008; Stroulia et al 2017), 2. grinding slabs with "open", unrestricted workfaces operating in combination with handstones of a length equal to the width of the stationary implement (Fig. 18.4a) (a variation of Type A in Bekiaris et al 2020), 3. grinding slabs with "open", unrestricted workfaces acting in combination with handstones of a length smaller than the width of the stationary implement (Fig. 18.4c) (corresponding with Type A in Bekiaris et al 2020). In the second and third case, the mobile counterpart performs again reciprocal, back-and-forth movements over the quern. Its manipulation may require the use of one or both hands, depending on the size and morphology of the handstone, 4. grinding slabs with a workface in the form of a circular or elliptical basin/cavity (Fig. 18.3b), combined with a small, single-hand grinder (Fig. 18.4c) that performs "free"/curvilinear moves within the concavity (corresponding with Type C in Bekiaris et al 2020). The first three sets are encountered more frequently in the archaeological record. The fourth set occurs only with a few specimens on some sites (e.g. Avgi: Bekiaris 2018, Kleitos: Chondrou 2020; Franchthi: Stroulia 2010). So far no spatial or temporal patterns can be observed in the distribution of the Type d implements (cf Bekiaris et al 2020).

Pounding toolsets also comprise two counterparts: the *mortar*, a lower, hollowed stone, serving as the recipient of the processed material, and the *pestle*, the upper, elongated, usually cylindrical handstone, that pounds, crushes, rubs or mixes the substance(s) within the mortar's hollow. In contrast with grinding slabs and grinders that are usually made out of stone (but see Delgado-Raack and Risch 2009), mortars and pestles can also be made of non-lithic materials (see the wooden pestles at the LN lake-site of Anargyroi XIIIa, Chrysostomou et al 2015, the bedrock cuttings that have served as mortars at EN Paliambela, Tsartsidou and Kotsakis 2020, and the clay-lined depression at Late Neolithic Thermi B, Valamoti 2009). Stone mortars and pestles are rarely encountered in the Neolithic of Greece and the Balkans. Therefore, no specific types have been recognized in the archaeological assemblages (cf. Bekiaris et al 2020).

18.2 A brief overview of grinding technology in the Neolithic of Greece and the Balkans

The grinding toolkits from Neolithic Greece and the Balkans exhibit great variability, regarding their technological characteristics, manufacturing techniques, curation and destruction patterns. These issues are discussed in greater detail in Bekiaris et al 2020, so only a brief overview of an introductory character is presented here.

Durable and hard raw materials, with uneven, rough textures, like sandstones, micro-conglomerates, gneisses, schists, granites and andesites collected from secondary local sources (e.g. rivers, streams) were usually favored for the production of the grinding tools (for an overview see Bekiaris et al 2020). Certain neolithic communities seem to have developed specific preferences on the exploitation of particular lithic resources, usually located in their immediate landscape (e.g. Koromilia: Bekiaris pers. observ.; Avgi: Bekiaris 2018, 2020; Makriyalos: Tsoraki 2008; Dikili Tash: Chondrou, pers. observ.; Makri: Bekiaris 2007), while others chose to exploit a broader array of lithic materials for their toolsets (e.g. Megalo Nisi Galanis: Fotiadis et al 2019; Kleitos: Chondrou et al 2018). The predominance of local lithic materials, obtained directly from the wider region of the neolithic settlements appears to be the norm for most neolithic communities (e.g. Avgi: Bekiaris et al 2017; Stergiou et al 2022), but non-local materials are also reported at some sites (e.g. Franchthi: Stroulia 2010; Sitagroi: Elster 2003; Dixon 2003; Makri: Melfos et al 2001).

The lithic materials were modified into grinding and pounding tools by employing percussive, reductive techniques, such as flaking and pecking, applied to shape the tools and create the workfaces (cf. Bekiaris et al 2020). Pecking was also extensively used for the rejuvenation of the dull workfaces of the grinding implements.

The morphological attributes of the neolithic grinding tools vary greatly, and they mostly include oblong plan shapes, oval or rectangular, but also circular, trapezoidal and triangular (e.g. Fig. 18.3 and 18.4). Most shapes reflect the natural water-rolled forms of the lithic materials. Significant variation is encountered in the profile shapes: planoconvex, concave/convex and rectangular profiles are usually the norm for the grinding slabs, with the handstones being often elliptical, circular, planoconvex or rectangular. Both larger and smaller toolsets have co-existed in the grinding inventories of most neolithic communities in Greece and the Balkans (cf. Stroulia 2018; Bekiaris et al 2020).

3 It should be stressed that the recognition of actual grinding pairs in the archaeological record of Greek and Balkan Neolithic is scarce (see Bekiaris 2018, 2020 for few rare examples of grinding pairs). Therefore, the restoration of the toolsets is based on the morphology of the passive and active contact surfaces and on the development of wear over their workfaces.

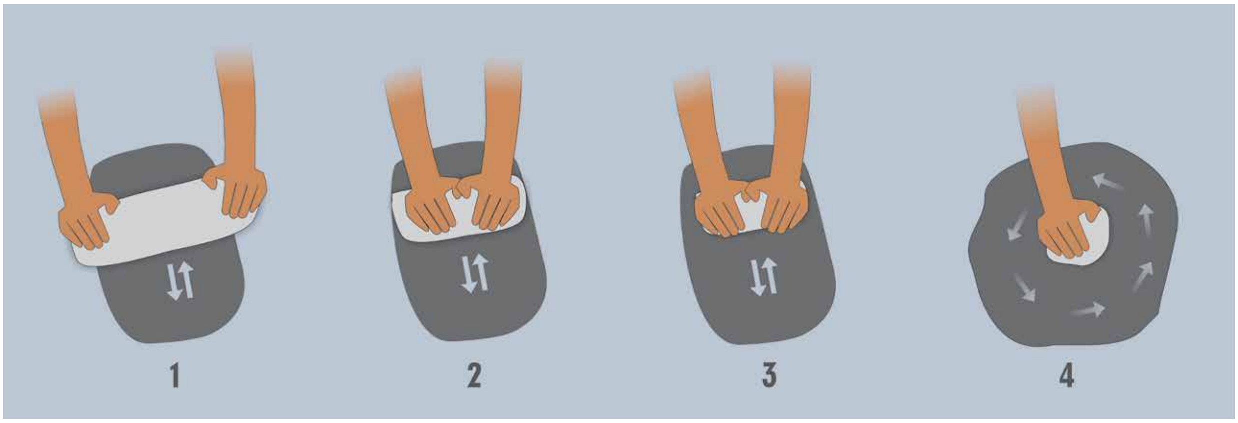

Fig. 18.2 Schematic representation of the four main variations of the Neolithic grinding pairs (modified after Bekiaris et al 2020; see also Bofill et al 2020, Table 1).

Fig. 18.3 Passive grinding tools. a open, reciprocal grinding slab from LN Stavroupoli (photo: Ismini Ninou); b basin, rotary grinding slab from LN Avgi (photo: Tasos Bekiaris).

Fig. 18.4 Active grinding tools. a Small-sized reciprocal handstone from LN Koromilia; b Large-sized reciprocal handstone from LN Avgi, c Small-sized, rotary handstone from LN Makri (photos: Tasos Bekiaris).

Most grinding tools lived complex use lives since they were consumed within the context of several activities and crafts (e.g. food-processing, mineral grinding, tool-making) usually shifting between multiple functional roles during their life-cycles. Their use-lives were often further prolonged through their transformation into new tool-types. For example, grinding slabs were often recycled as abraders or handheld grinders, while handstones often served a percussive function with their ends, as hammers. Another common recycling practice is incorporating intact or broken grinding tools in architectural features, such as buildings, thermal structures, pits and ditches, as we will discuss below. In some cases, the grinding tools were intentionally decommissioned through deliberate breaking or even burning (cf. Bekiaris et al 2020). The social and symbolic connotations of such practices may have varied and they have been already discussed elsewhere (e.g. Adams 2008; Bekiaris 2018, 321-323; Chondrou 2018, 393-410; Stroulia and Chondrou 2013).

18.4 Exploring the spatial contexts of grinding and pounding practices

In the Greek and Balkan Neolithic grinding tools are usually encountered within the habitation zones of the settlements. In most cases, the findspots of intact querns show a close association of the tools with the neolithic houses which may indicate that grinding practices such as the performance of the grinding task, the storage of grinding tools, the abandonment of grinding tools, were also spatially associated with the neolithic houses. Grinding implements are located either inside the dwellings (in the roofed, private space) or in the open areas surrounding them (in the un-demarcated, highly socialized space), thus expressing differences in the practicalities of performing the grinding/pounding task (e.g. seasonal grinding) and/or divergent forms of social behavior (grinding in private vs. grinding in public).

In Greece, archaeological evidence regarding the initial phases of the Early Neolithic (EN), although rather limited for the time being, strongly suggests that grinding practices occurred both in open and closed spaces (Bekiaris et al 2020; Ninou et al this volume). The absence of grinding implements from some sites and the employment of other technical means, such as mortars, to carry out the food-processing task is rather intriguing. For instance, in the EN deposits of Paliambela at Central Macedonia, cylindrical cavities dug into the bedrock at an open, communal area, have served as mortars, probably in combination with wooden pestles, for pounding and dehusking wheat inflorescences (Tsartsidou and Kotsakis 2020). Additionally, shallower bedrock basins, located near the pounding installations might have been used to grind grains. Different individuals could have worked simultaneously in these stable features, suggesting a certain degree of openness and sharing, implemented in the food-processing task (Kotsakis 2018; Tsartsidou and Kotsakis 2020, 172).

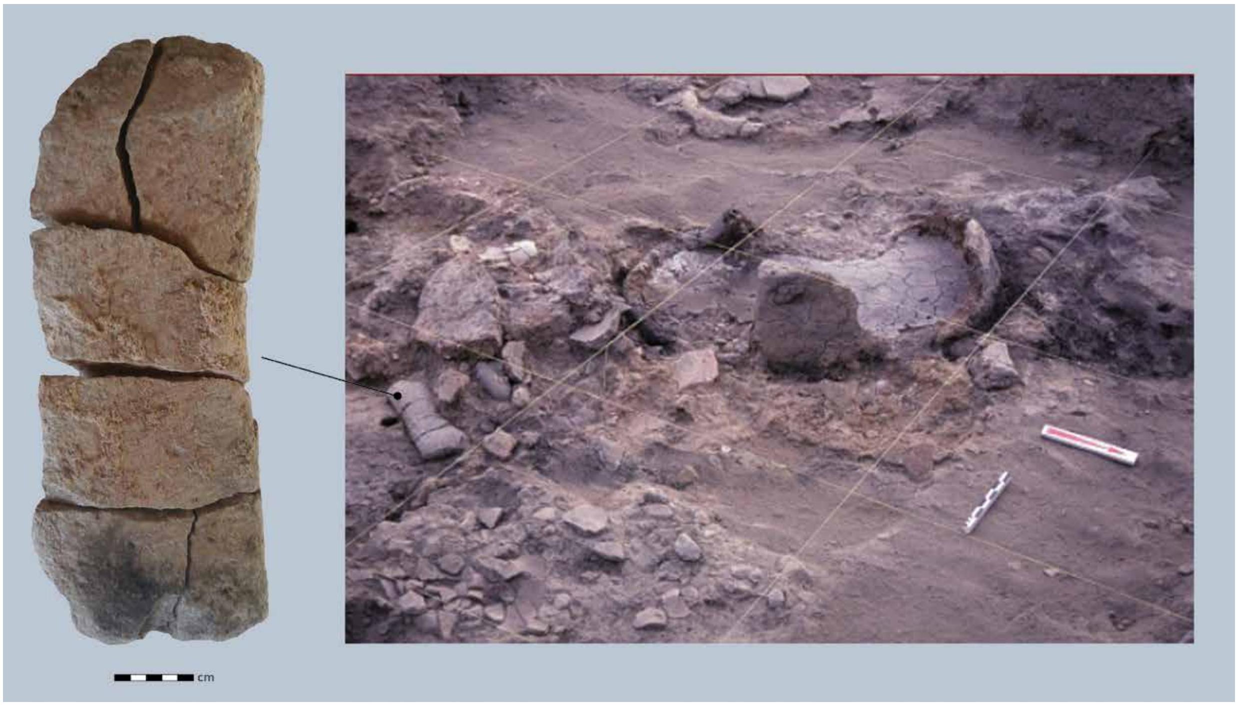

Fig. 18.5 Large grinding tool (left, photo: Danai Chondrou) within a burnt house at LN Dikili Tash (right, photo: Dikili Tash Excavations Archive).

At the EN site of Mavropigi-Fillotsari at Western Macedonia (Karamitrou-Mentessidi et al 2015), there is a clear preference in using mortars, over querns, which are encountered in minimal numbers. A bulky stone mortar with two shallow cavities was located inside an ellipsoidal roofed pit-dwelling, probably representing a stable feature of its equipment (Ninou et al this volume).

By contrast, several other sites belonging to the more advanced phases of the Greek EN (e.g. Sesklo, Achilleion, Sossandra and Nea Nikomedeia) have yielded almost exclusively grinding tools (cf. Bekiaris et al 2020), both from the interior of houses and from outdoor areas, indicating the prominent role of these implements and their associated tasks for the early farming communities in Greece. Among these cases, EN Sossandra in Central Macedonia (Georgiadou 2015) stands out as a rare example, since a large number of grinding tools (19 grinding slabs and six handheld grinders) were located inside a single, rectangular, three-partite house. Most grinding implements were unearthed in the central area of the house, in the periphery of a grain storage pit, while they were absent from the eastern partition of the building, where cooking practices took place (Georgiadou 2015). Different persons could have worked simultaneously with this equipment, although it is yet unclear whether all these grinding tools were used in the context of food-processing tasks, or even if they were all used inside the building or they were just kept there.

In the case of EN Ayios Vlasis, Central Greece, on the other hand, the small excavation brought to light a diverse stone tool assemblage that included both grinding and pounding implements, suggesting the pronounced importance of both in the productive activities of the community (Chondrou, pers. obs.).

Further to the North, in the EN site of Yabalkovo (Leshtakov et al 2007) mortars were found fixed on the floors of almost all excavated dwellings, often along with portable grinding stones. Interestingly, food-processing stone tools are not reported from the outdoor food-preparation areas of the site (Leshtakov et al 2007, 193).

The close association of the grinding practices with the domestic sphere and the house becomes more evident during the subsequent Middle and Late Neolithic (MN – LN) of Greece and the Balkans for which more evidence is available. In LN Makri, Thrace, for example, grinding tools were found within the habitation area of the site, next to the houses or in their interior, while they seem to be rare on the top of the neolithic tell, where a communal storage area has been excavated (Bekiaris 2007). Similarly, grinding tools in LN Makriyalos, Central Macedonia, were found near or inside the pit clusters, which probably represent domestic units (Tsoraki 2007, 2008; Pappa et al 2013).

The recurrent presence of grinding implements within the neolithic houses and in their immediate surroundings suggests that the grinding task becomes an indispensable part of the daily routines organized and practiced by individual domestic units/households. Grinding tools were located inside houses in EN/MN Čavdar, MN Cerje-Govlrevo, LN Divostin, LN Makri, LN Dikili Tash (Fig. 18.5), LN Makryialos, MN/LN Servia, LN Kleitos, LN Avgi, LN Dispilio, MN Sesklo, LN Rakhmani to mention but a few examples. Most of these houses were equipped with one or two grinding pairs[4] a rather modest number that may indicate the domestic, small-scale character of production. We can assume that grinding activities were performed in the areas where the tools were found although other areas might have been associated with such practices and these tool kits could have been transported within the settlement depending on the needs and the grinding/pounding occasions.

Within the neolithic house, grinding tools and more rarely stone pounding implements are found in direct spatial association with cooking installations, such as hearths and ovens (e.g. EN Slatina-Sofia, MN Cerje-Govrlevo, MN Servia, LN Balgarchevo, LN Vinca, MN/LN Stavroupoli, LN Dispilio), pointing to the existence of interior kitchen spaces (cf. Kalogiropoulou 2013, 75). Within some houses a different spatial arrangement of the grinding and cooking practices can be traced. For instance, in LN/FN Kleitos in Western Macedonia, grinding tools are usually located in either central or marginal areas of the interior domestic space, lacking a direct association with thermal structures (Chondrou 2020; Chondrou and Valamoti 2021). As discussed above, a similar arrangement was also observed in the EN house of Sossandra (Georgiadou 2015). This pattern probably reflects certain choices, on how different stages of the food preparation task (i.e. food grinding, cooking) were temporally or spatially organized in the neolithic domestic space (cf. Chondrou 2020, 302).

In some houses, grinding tools occur in relation with agricultural products, either stored crops or processed seeds, and clay pots used for cooking or storage, suggesting that several steps of the food preparation process (i.e. grain processing, cooking, storage) could have been performed in the interior of individual neolithic dwellings, perhaps underlying the privacy of house interior spaces. MN/LN Avgi in Western Macedonia constitutes a good example of this pattern since grinding slabs were found in the interiors of some houses along with clay pots and small concentrations of "clean" agricultural products (*Triticum dicoccum* and *Lathyrus sativus-cicera*), some of which have been submitted to pounding or coarse grinding and may represent foodstuffs in the form of cracked wheat or bulgur (Bekiaris 2018, 2020; Stratouli et al 2020).

Besides the repeated association of the individual, sheltered domestic space and grinding practices, several examples indicate the extension of these tasks beyond the walls of the neolithic house in the open areas of the settlements. Grinding in open, exterior spaces is testified at several sites, such as LN Selevac, LN Makri, LN/FN Kleitos, MN/LN Servia, LN Koromilia and MN/LN Avgi. Sometimes, grinding tools are located directly in association with individual houses, perhaps indicating that they were ascribed to specific households. Such an association is evident in the case of MN/LN Servia, where grinding tools occur in small, enclosed yards attached to specific dwellings. In MN/LN Avgi, specifically in the AVGI I phase (MN/LNI), grinding tools are encountered more frequently in the open areas between the buildings, than in their interior (Bekiaris 2018, 2020). Thus, it seems that grinding took place in the immediate periphery of the houses, usually in a close spatial reference with it, but still in public view, in communal areas of high social interaction, along with several other daily practices (e.g. cooking, the manufacture and repair of various objects, refuse disposal). Open-air grinding locales, that are not spatially associated with any building, can be also traced by the presence of small groups of intact grinding tools, found in the periphery of open-air kitchen spaces, but not directly next to the cooking facilities (Bekiaris 2020). This spatial pattern changes during the AVGI II phase (LNI), with the grinding tools now encountered right next to the outdoor cooking facilities (Fig. 18.6). This change may suggest a swift towards a more pronounced sense of individuality or ownership and could indicate that different forms of socialites (i.e. collectivity or individuality) could have been manifested and expressed in these open areas (Bekiaris 2018, 2020; Kalogiropoulou 2013; Stratouli et al 2020).

All the above cases indicate the spatial contexts in which the neolithic grinding practices would have regularly occurred. However, they do not necessarily suggest that the food-processing tasks were spatially fixed practices, bounded to specific areas of the neolithic built environment, neither that these spatial preferences remained unchanged throughout the lives of the neolithic communities. On the contrary, such activities should be perceived as dynamic and spatially flexible processes, affected by numerous variables, altering their spatial form over time. Most grinding tools are portable items that could be rather easily transported to different spaces to support various needs. Therefore, their contexts may have regularly (or maybe seasonally) switched between the house interior and exterior, as has already been suggested for sites like LN Makriyalos (Tsoraki 2007), LN/FN Kleitos (Chondrou 2020) and MN/LN Avgi (Bekiaris 2020). As documented by various ethnographic examples, the reasons for shifting the location of grinding tasks may have varied: weather conditions, the mood of the individual who carries the task, particular demands of the grinding practice, like the management of the end

4 Only the intact grinding implements that were probably unearthed *in situ* at the interior of the neolithic houses are considered here.

Fig. 18.6 Grinding set (quern and handstone) located at an open area in LN Avgi (photo: Tasos Bekiaris, Neolithic Avgi Excavations Archive).

product, or even the grinding for special social occasions, such as gatherings, rituals or feasts (see Tsoraki 2008; Chondrou 2020 and references to some ethnographic examples therein).

In contrast to this spatial fluidity of the grinding practices are the pounding and grinding installations, where the passive stone component is placed on a fixed clay basin or on a clay base, or it is sunken within an activity surface/floor. Such findings, however, are rather rare in the Neolithic of Greece. Besides the large, immovable mortar from EN Mavropigi-Filotsairi, discussed above, MN Paliambela constitutes another intriguing case. Immovable stone mortars were located inside some MN houses at Paliambela, perhaps carrying on the pounding tradition that had characterized the food-processing practices of the EN community (Tsartsidou and Kotsakis 2020). The mortars had an additional high clay lip on their rim and one of them was unearthed alongside a cooking pot and a thermal structure that may have been used for cooking (Siamidou

Fig. 18.7 Grinding set (quern and handstone) next to a clay basin/receptacle within a pit-dwelling in MN/LN Stavroupoli (after Kotsos 2013).

2017). However, it should be stressed that not all MN houses at Paliambela were equipped with stone mortars and that portable grinding tools were also extensively used (Tsartsidou and Kotsakis 2020, 13).

The most well-preserved example of a grinding installation from Neolithic Greece is known from MN/LN Stavroupoli, Central Macedonia (Fig. 18.7). The installation was located within a pit-dwelling, next to a thermal structure, and it consists of a clay basin, that may have acted as a receptacle for the processed material and a grinding set (quern and handstone) which was placed on the basin's rim (Kotsos 2013, 2017). Furthermore, in MN Lerna, Southern Greece, a grinding platform was found inside a house (Banks 2015, 184), while at LN/FN Kleitos there is possible evidence for a few grinding installations in some of the open areas (Chondrou 2020, 301).

Contrary to their limited presence in the archaeological record of Neolithic Greece, fixed grinding installations seem to be a norm for several neolithic sites in the Balkans. In LN Stubline in Serbia, grinding installations are found in the interior of houses and are associated with ovens (Fig. 18.8). They are described as "shell-shaped" structures consisting of a shallow clay receptacle with an upright clay base for a fixed or movable grindstone (Crnobrnja 2012; Spasić and Živanović 2015). Moreover, in LN Medgidia in Romania, in the interior of a room, three grinding slabs were placed on a clay base, while next to them five portable grinding implements were recovered (Marinescu-Bîlcu 2000). The grinding equipment was also associated with several storage vessels. Similar findings are reported from many other Balkan neolithic sites, including EN/MN Čavdar in Bulgaria, MN Cerje-Govrlevo, LN Divostin and LN Vinca in Serbia. In all cases, the grinding

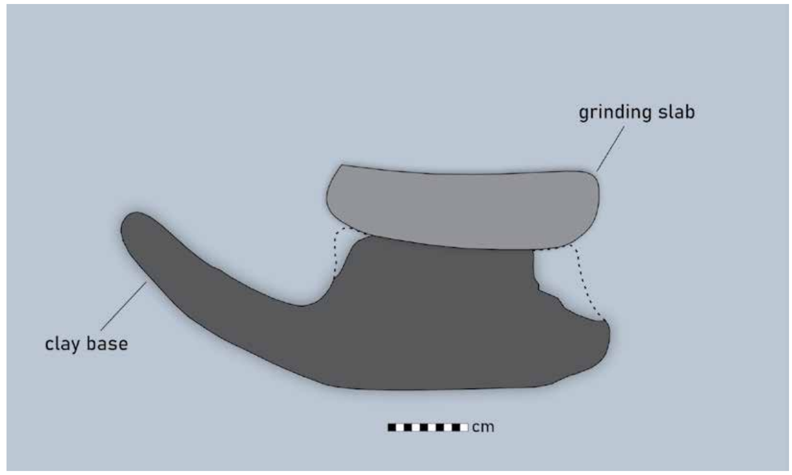

Fig. 18.8 Schematic drawing of a grinding installation from LN Stubline (drawing: Tasos Bekiaris, after Spasić and Živanović 2015).

installations were located inside individual dwellings. In MN Porodin such features were unearthed in an open space (Grbić 1960, 15; Kotsos 2018, 138).

The existence of fixed, specialized grinding areas within the Balkan neolithic house is further attested at several neolithic sites in Romania by grinding tools placed inside clay boxes or small grinding areas delineated by clay borders (cf. Burdo et al 2013). In MN Tumba Madžari and MN/LN Zelenikovo, in North Macedonia, grinding implements were embedded in clay tub-like recipients (Stojanova-Kazurova and Rujak 2016).

Some researchers assume that such installations may have been used for grinding on special occasions (Stojanova-Kazurova and Rujak 2016), in contrast to the daily grinding which may have been performed with portable tools. Such an intriguing case is known from MN/LN Parta in Romania. A hand-mill/mortar was found in the outside wall, next to the entrance of a two-roomed building with bull figurines that was characterized as a "shrine". According to the authors (Lazarovici et al 2002), the tool was fixed on the building's wall along with a clay cup, acting as a receptacle for the ground cereals which were interpreted as offerings[5] for deities (Lazarovici and Lazarovici 2010).

18.5 Contexts of recycling, destruction and deposition

As already discussed, neolithic grinding tools may have had complex biographies, with a series of subsequent life stages that expanded their lives, beyond their primary uses and beyond their primary contexts of consumption. Tools appear to have been often reshaped to be incorporated into a new context of use. For example, in several neolithic sites (i.e. LN Makriyalos, MN/LN Avgi, LN/FN Kleitos) cases of grinding slabs that were remodified into handstones have been detected. Recycling (as defined in Stroulia 2010) constitutes another example of secondary employment of grinding implements. In this case, the tools either acquire a totally different functional role (i.e. handstones used as hammers, grinding slabs used as grooved abraders) or their use as implements cease and they are incorporated into a radically new context. At MN Servia, for example, grinding tools have been used as packing material in postholes and foundation ditches (Mould et al 2000). At LN Drakaina Cave, in Kephalonia Island intact grinding slabs were used to delineate a hearth (Bekiaris pers. observ.), while in the LN layers of Knossos, on the Island of Crete, grinding slabs were placed into the foundations of walls or within other structures (Evans 1964). Moreover, grinding implements have been incorporated into thermal clay structures, as part of the structure's floor or its substructure, a pattern detected at sites both in Northern and Southern Greece (e.g. Kleitos: Chondrou 2020; Franchthi: Stroulia 2010). It has been suggested (e.g. Rosenberg 2013), that such practices may not serve mere practical needs, such as the need to recycle old tools as building material, but should be instead associated with symbolic acts, bounded to the social and economic meaning that the grinding implements had acquired during their use-lives.

At several neolithic sites across Greece and the Balkans, grinding implements are often found buried within cuttings, such as pits and ditches, usually alongside other elements of the neolithic material culture (i.e. pottery, figurines, animal bones, seeds, other tools). Some of these features and contents have been interpreted as "special" or structured deposits. In these cases the association of fragmented and intact grinding implements appears to be of special significance and the diversified types of tool treatment, before their deposition, may have held a special or even symbolic meaning. A very characteristic example is LN Toumba Kremasti Koilada, in Northwestern Greece (Hondroyianni-Metoki 2009, 2015). A huge set of 462 pits filled with anthropogenic material, amongst

5 For the issue of "sacred grinding" see (Lazarovici and Lazarovici 2010) and references therein.

which hundreds of grinding tools, were associated with the periphery of a low tell-settlement. Before their disposal inside the pits, many of the artifacts had been exposed to fire or were deliberately broken, as suggested by thermally induced alterations and visible breaking marks. Others were fully functional, yet decommissioned through their deposition and burial into the pits (Fig. 18.9). Conjoining parts of the same artifact have been deposited in different pits, a practice that further highlights the intentionality behind the structure of these deposits (Chondrou 2011; Stroulia and Chondrou 2013).

Several grinding tools were recovered from pits in LN Avgi (phase Avgi III, Late Neolithic II). Some of these deposits may have occurred within a ritual context (Stratouli et al 2014, 2020). This is probably the case of Pit 282302, where a small grinding slab was deposited alongside 70.000 charred seeds of emmer wheat and some pieces of building material. In contrast to the seeds, neither the grinding slab, nor the walls of the pit had any traces of burning (Bekiaris 2018, 2020). The micromorphological analysis confirmed that the seeds were not burnt *in situ*, but before their deposition (Fig. 18.10). Furthermore, their disposal within the cutting occurred at multiple episodes in the life history of the pit (see Stratouli et al 2020, 98).

Grinding equipment, often fragmentary, is a common find in the filling of cuttings, interpreted as "ritual pits", identified in the Balkans, especially in Bulgaria and Romania. According to their excavators, these features were probably linked to ritual practices associated with fire and sacrificial food. They are rich in ashes, charcoal and food remains, animal bones or horns, pottery, flint tools and possible "cult objects", such as altars (for further details see Nikolov 2011, 2015). A "ritual pit" is also reported from the EN site of Miercurea Sibiului-Petriş, in Romania. The pit contained cattle and aurochs horns, and animal bones, sealed with cobbles and fragments of hand mills (Luca et al 2009). Additionally, a "grinding stone cache" consisting of thirteen grindstones and a mortar have been deposited inside a pit from LN Selevac (Spears 1990, 503). However, no further details regarding the preservation of the artifacts are mentioned. Finally, in the Northern Balkans, in the LN site of Vermesti in Romania, a special deposit containing worn fragments of grinding stones along with intact and still usable specimens was recovered underneath a house floor (Chapman 2000).

The contents of other neolithic pits could perhaps be the outcomes of open, public events of food consumption, which have also included the conspicuous destruction of grinding implements (and other artifacts) that may have held significant parts in the tasks performed during the event (e.g. the preparation of foodstuffs). At LN Makryialos, the contents (i.e. animal and fish bones, pottery, ground stones) of the so-called Pit 212 indicate a large-scale collective consumption episode of animal-based food, that probably exceeds the limits of the neolithic community (Pappa et al 2013). Among them was a large concentration of fragmentary grinding slabs that were probably destroyed in the context of the event, as an act of conspicuous and wasteful consumption (Tsoraki 2008).

At EN Achilleion, Thessaly, on the other hand, excavations revealed remains of a possible event, perhaps of a communal character, related to food preparation and consumption in an open area of the settlement, between the houses. The area includes a large platform, a big pit, a thermal structure and a yellow plastered floor surrounding the platform. Several broken querns were deposited on the floor and the nearby pit, among animal bones and painted vessels, maybe pointing again to the conspicuous destruction of objects that have participated in the event (cf. Gimbutas et al 1989, 47-50; Kotsakis 2018).

The association of grinding tools in funerary contexts is rarely identified in Neolithic Southeastern Europe. In Northern Greece, LN Makri offers two such examples. A burial uncovered beneath a plastered floor includes the skeleton of an individual, in a typical contracted position, and a large grinding slab found resting on its neck (Efstratiou 1998, 28). A second burial included a pair of grinding tools (Bekiaris 2007, 68), probably placed with the dead as grave goods (Fig. 18.11). More examples originate from Southern Greece. In Alepotrypa Cave, a grinding slab was found alongside a female burial (Stroulia 2018, 204), while in Ayioryitika in Arcadia grinding slabs were placed near the heads of the deceased and may have served as "pillows" (Petrakis 2002, 57).

In Romania, both intact and fragmentary grinding stones were found within a burial in LN Traian (Chapman 2000, 93), while in LN Mangalia, at a Hamangia culture cemetery, part of a heavily used grindstone was located in the interior of a grave (Volshi and Irimia 1968).

In the above cases, grinding tools that may have originated from various contexts (i.e. house interiors, open areas), employed in several tasks (i.e. food preparation, pigment processing), related to different social groups and events (i.e. domestic or individual consumption, communal events), end up being deposited in non-utilitarian, secondary contexts. Intact, broken, burnt and unburnt implements were selected and disposed within these cuttings, alongside other objects and materials. Through such acts, new material entities were formed. The scope and meaning of these practices may have varied: from foundation rituals, closing rituals or destructive acts, to commemorative practices tied to specific memories, persons and moments, or to feasting events of various scales (for similar interpretations see Hamon 2008, 2020; Hodder and Cessford 2004; Stroulia and Chondrou 2013; Tsoraki 2008, 2018).

Fig. 18.9 Pit from LN Toumba Kremasti containing miniature pots and a grinding slab (after Hondroyianni-Metoki 2015).

18.6 Discussion

Around the mid-7th mill BC grinding and pounding implements appeared in the material culture of the first farming communities of Greece (cf. Bekiaris et al 2020) and the Balkans, playing a significant part in the lives of the neolithic people, through their implication in several tasks and aspects of their daily routines. The need to produce, use, curate and manipulate this equipment regularly, generated various entanglements and associations between the people and the landscape (i.e. the identification and exploitation of the proper natural resources, cf. Bekiaris et al 2017), but also between the stone processing tools and the domestic environment, the cooking facilities and the plant foods (cf. Hodder 2017). The daily grind led to the establishment of networks of (inter)action among different practices (e.g. food-processing, cooking, storage, eating, sharing) and various technological products of the neolithic material culture (e.g. pottery, basketry, wooden, bone or stone implements) and their agents. Through their manipulation and curation, the grinding tools also became the means for forging and conveying symbolic meanings and displaying social relations and identities (Stroulia and Chondrou 2013; Tsoraki 2008).

Our approach aimed on highlighting the contextual associations of grinding and pounding tools on an intra-settlement level. Our research presented here has focused only on selected archaeological examples, carefully chosen, to illustrate all the norms and divergences regarding the spatial and social contexts of the grinding/pounding implements and their associated practices in the Neolithic of Greece and the Balkans.

Grinding is spatially linked to the domestic domain, mainly the neolithic house and its surrounding open areas, forming a vital element of the neolithic household's economic and social activities. The spatial emphasis on the house is documented by the repeated presence of grinding tools and more rarely pounding implements, within the neolithic dwellings. It seems that grinding implements represent a typical, standardized piece of the productive equipment of several neolithic houses across Greece and the Balkans and that the household forms the primary social unit that organizes and carries out the grinding practices. The grinding task might have been performed within the privacy of the neolithic dwelling, along with other food-related practices (e.g. storage, cooking, eating), as suggested by the correlated finds (e.g. cooking and storage pots, plant-food remains)

Fig. 18.10 Small grinding slab placed vertically on the walls of a pit at LN Avgi. Besides the grinding slab, the pit contained more than 70.000 charred seeds of emmer wheat and building material (photo: Tasos Bekiaris, Neolithic Avgi Excavations Archive).

Fig. 18.11 Grinding set (quern and handstone) from a burial at LN Makri (photo: Tasos Bekiaris).

and architectural features (e.g. hearths, ovens). The number of grinding tools per house and their sizes (cf. Bekiaris et al 2020) indicate the small-scale, domestic character of the food-preparation process, which commonly aimed to satisfy the needs of small social groups. Some intriguing exceptions, such as the EN house of Sossandra, which has yielded 25 grinding tools (Georgiadou 2015), may indicate that this dwelling and its grinding equipment were part of a more extended household, that may have necessitated the use of a larger inventory of grinding tools or that the grinding tools were intended for special occasions during which a large quantity of plant foods needed to be ground.

In contrast to this possible aspect of grinding in private, several examples indicate that the grinding task was also performed in the open, communal areas between the neolithic houses. Grinding in the open, certainly ascribes a more commensal character to the task, which is performed at public sight, along other crafts, experienced or shared by people who do not necessarily live under the same roof. The portable sizes of most grinding tools would have undoubtedly allowed them to switch between workspaces and social domains, perhaps in different seasons (winter vs. summer) or to support various needs. Some examples of large, immovable stone tools, and grinding and pounding installations, which contrary to Greece appear rather often in the Balkan Neolithic, suggest spatially fixed practices that were performed in specific workspaces, within the built environment.

Significant variation is detected also in the manipulation of these artifacts beyond their primary use(s). Grinding tools appear to have been subject to secondary tasks, as indicated by their regular reshaping and recycling to be consumed within a different use context. Their post-usage manipulation may have included burning or breakage, their incorporation within architectural features (e.g. walls, clay structures) or deposition in special contexts (e.g. pits, ditches, burials), practices that can convey variable meanings. In these cases, implements that may have originated from various social contexts, private or communal, carrying their own, diverse life histories, became interconnected within the context of their deposition. Through the selective disposal of grinding stone tools inside the cuttings, accompanied by other material elements, remnants of various past events, each with its own biography, new material entities were forged and meanings related to continuity, ancestry, and place-making were probably generated. Thus, grinding and pounding implements were involved in commemorative history-making through their manipulation and deposition into such features in our study area as has also been observed for other parts of Europe and Western Asia (cf. Hamon 2008; Hodder and Cessford 2004; Tsoraki 2018).

Finally, other cases indicate the occasional participation of the grinding tools in open events related to food preparation and consumption. Besides the communal consumption of food, these events could have also included the conspicuous, wasteful consumption of elements of the material culture, mainly grinding implements and pottery, and their burying within pits. It has been proposed, that through such acts, communal identities would have emerged over individual identities (cf. Triantaphyllou 1999; Tsoraki 2008, 2018).

The various archaeological examples presented in this paper indicate the complex and diverse character that grinding practices, and by extent food-processing tasks, had acquired within the different spatial contexts and sociocultural environments of Neolithic Greece and southeastern Europe. Moreover, it stresses the need to study grinding tools in relation to other features of the domestic environment, like the house, or socioeconomic concepts, such as the household, but also with other material components of the food-preparation process, such as ovens, cooking pots, and plant food remains, with which grinding tools are usually associated within the neolithic settlement space. Inside or outside the neolithic house, within pits or burials, either few or many, stable or not, grinding tools constituted an integral part of the neolithic domestic sphere. The daily grind was indeed a fundamental practice of the neolithic social life.

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Chapter 19

Cooking on the rocks? An interdisciplinary approach on the use of burnt stone slabs from Neolithic Avgi, Kastoria

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In memory of Vassiliki Liousi

Abstract

Excavations at Neolithic Avgi (ca 5700/5500-4700-4300 cal BC), in the region of Kastoria, NW Greece, brought to light thousands of macrolithic (or ground stone) artifacts. Besides the common macrolithic types (i.e. grinding tools, edge tools, polishing tools, abrading tools etc) the assemblage includes an intriguing group of 63 burnt fragments of sandstone slabs. The use of these implements is enigmatic, but the recurrent presence of burning traces on them could suggest that it was somehow related to fire activities. To the present day, similar artifacts are not reported from any other Neolithic site in Greece. In this chapter, we present these rare finds and try to understand their use(s) through the macroscopic analysis of their technological attributes, their spatiotemporal distribution within the neolithic site, the petrographic identification of their raw materials and also through experimentation. Our results are further corroborated by observations on the use of similar slabs as cooking surfaces for the baking of pies, documented by traditional practices in the region of Kastoria, as well as in other regions of Greece.

Keywords: *neolithic Greece, neolithic Avgi, macrolithics, stone slabs, cooking slabs*

19.1 Introduction – The site, the macrolithic assemblage and the stone slabs

Neolithic Avgi is an extended site of ca 5.5 hectares, located at a semi-mountainous area in the region of Kastoria, NW Greece. Excavations at the site were conducted for seven consecutive seasons (2002-2008) by the Hellenic Ministry of Culture under the direction of Dr. Georgia Stratouli (cf. Stratouli 2005, 2007, 2013; Stratouli and Bekiaris 2008; Stratouli and Kloukinas 2020; Stratouli et al 2011, 2014, 2020), covering an area of ca 2000 m^2. They have revealed the diverse occupation remains of a significant Neolithic settlement, such as houses, open areas, thermal structures, cooking installations, pits, ditches, burials, dietary remains, pottery, tools, figurines, ornaments and other objects, dated to the Middle and Late Neolithic, ca 5700/5500–4500/4300 cal BC. Three stratigraphic phases (AVGI I:

in: Valamoti SM, Dimoula A, Ntinou M (eds) 2022, Cooking with Plants in Ancient Europe and Beyond: Interdisciplinary approaches to the archaeology of plant foods, Leiden: Sidestone Press, pp. 319-334

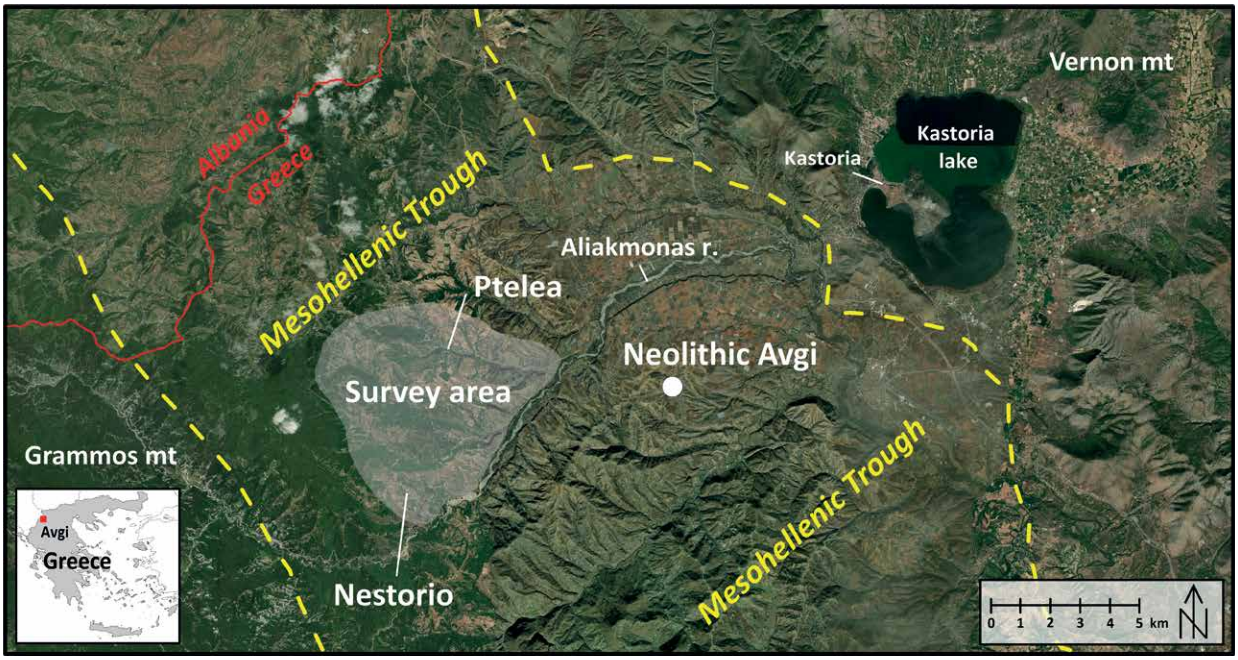


Fig. 19.1 Satellite image of the broader area of Avgi. Major mountains and the Mesohellenic Trough are mentioned. The survey area between Ptelea and Nestorio is highlighted. The location (white cycle) of the Neolithic site of Avgi is shown (satellite imagery: Esri 2020, plan: Ch. Stergiou).

MN/LN, AVGI II: LNI and AVGI III: LNII) were recognized in the site's sequence (cf. Stratouli et al 2020).

Among the numerous mobile finds, excavations at Neolithic Avgi (Fig. 19.1) brought to light an impressive macrolithic assemblage, comprising approximately 8000 artifacts. The study of the assemblage has so far focused on the macroscopic, microscopic and contextual analysis of ca 3000 macrolithic artifacts deriving from undisturbed neolithic deposits (Bekiaris 2018, 2020, in prep) and on the petrographic investigation of their raw materials (Bekiaris et al 2017; Stergiou et al 2022). Besides artifact types, such as grinding tools, polishers, abraders, pounding tools, and edge tools, commonly encountered on the macrolithic industries of other northern Greek Neolithic sites (e.g. Alisøy 2002; Almasidou 2019; Bekiaris 2007; Chondrou 2011; Elster 2003; Stratouli 2002; Stroulia et al 2017; Tsoraki 2008), the assemblage from Neolithic Avgi includes some previously unknown macrolithic categories. The most prominent and intriguing case concerns 63 fragments of thin sandstone slabs. The exact use of these slabs is not clear, but the recurrent presence of burning traces on their surfaces might suggest their functional association with fire.

In this paper, we discuss these rare macrolithic finds, seeking to comprehend their use(s) through an interdisciplinary analytical approach. Our analysis is based on the technological attributes of the stone slabs, as documented by their macroscopic examination and on their contextual associations with other finds and spatial features (e.g. houses, open areas, thermal structures, pits). In addition, we review their petrological characteristics and present possible regional sources of their raw material (cf. Stergiou et al 2022). Our results are discussed in comparison to observations on the use of stone slabs as cooking surfaces (*pitoulnitses* in Greek), for the baking of pies (*pitoulkes* in Greek), documented in the local tradition of Kastoria, as well as in other regions of Greece. Finally, we present the experimental reproduction and use of slabs as cooking utensils, conducted within the course of educational activities regarding food preparation and cooking practices at Neolithic Avgi (cf. Stratouli et al 2013).

19.2 The technology of the stone slabs

The macrolithic assemblage from Neolithic Avgi includes 63 stone slabs[1]. These artifacts derive from all stratigraphic phases of Neolithic Avgi: 17 items from the deposits of AVGI I, 32 from AVGI II and 13 from AVGI III (for a detailed description of the stratigraphic phases see Stratouli et al 2020). Most stone slabs (55 artifacts) were found in the Western Sector of the site. Five items came

1 Given that the site's unstratified macrolithics (e.g. finds deriving from the heavily truncated topsoil) are yet to be studied, the overall number of the stone slabs from Neolithic Avgi might prove to be significantly larger.

Fig. 19.2 Fragment of a burnt stone slab. Ventral (smoothed) face, length section and dorsal face (photo: T. Bekiaris).

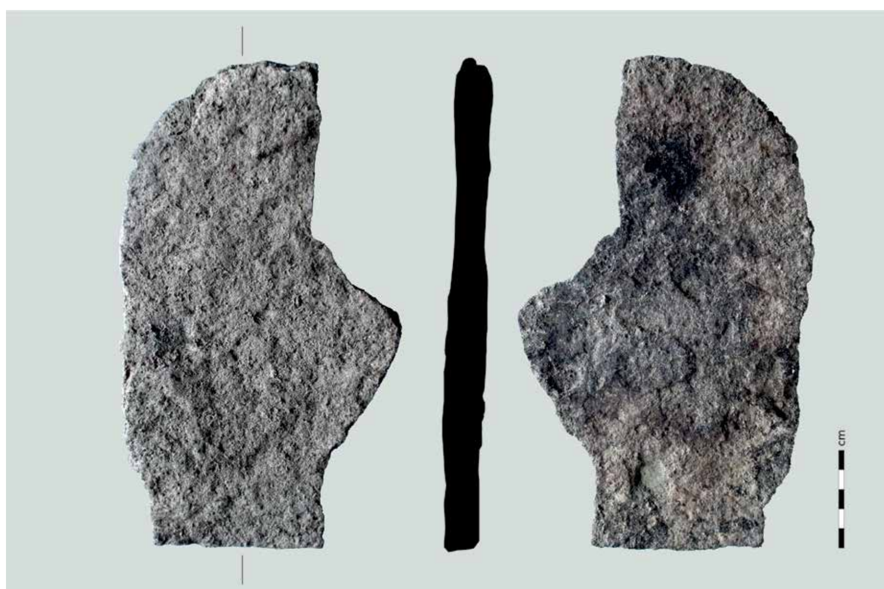


Fig. 19.3 Fragment of a burnt stone slab. Ventral (un-smoothed) face, length section and dorsal face (photo: T. Bekiaris).

from the Central Sector and three from the East Sector (see also Bekiaris 2018).

All the studied items do not exhibit any signs macroscopic use-wear that could clarify their function or indicate an association with any other macrolithic categories (e.g. grinding tools, polishers, abraders). Besides the absence of distinct use-wear, these slabs share several other technological characteristics regarding their raw materials, preservation, morphology, manufacture and the recurrent presence of burning traces that justify their typological homogeneity.

According to the petrographic analysis of the artifacts (see below), fine-grained sandstone constitutes the main lithic material for all but one of the analyzed slabs. The exception concerns a single specimen, which was made of schist. The stone slabs were either extracted or collected from local primary outcrops, consisting of thin (<5 cm in thickness) sandstone beds (Stergiou et al 2022).

The preservation of the stone slabs is characterized by extreme fragmentation (Fig. 19.2, 19.3). All specimens appear severely broken, with the majority of fragments probably representing only a small portion (<25%) of the original implement. In contrast to other macrolithic groups, such as the grinding and edge tools, usually deliberately broken (cf. Bekiaris 2018, 312-324; Bekiaris 2020; Bekiaris et al 2020; Stroulia and Chondrou 2013; Tsoraki 2008) in the context of destructive acts or curation practices (e.g. recycling, redesign), the fragmentation of most stone slabs seem to have been accidental. No impact points and no fragmentation patterns (cf. Adams 2008; Bekiaris 2018, 318-324; Stroulia and Chondrou 2013) that would imply their intentional breaking were recognized. The small thickness (<3 cm) must have made these artifacts extremely vulnerable and their regular exposure to fire must have amplified the risk of breaking (i.e. heat cracking, breaking due to thermal shocks).

The preserved lengths of the stone slabs range between 4.4-23.7 cm (median=9.4 cm) and their preserved widths between 2.7-13.5 cm (median=7.2 cm). Their thickness rates from 1.0 to 4.7 cm (median=2.2 cm), with most specimens (59 items) measuring less than 3 cm. The actual sizes of the stone slabs can be only inferred through a single, nearly intact sandstone slab that has been used as a grooved abrader. This implement, which was retrieved from the interior of a pit, is quite large, measuring 53.0 cm in length, 30.0 cm in width and 3.5 cm in thickness, while it weighs more than 11 kilos. Given the extremely fragmented state of most stone slabs, it is plausible to hypothesize that some had similar dimensions. Large-sized slabs can be found in the sandstone outcrops of the Ptelea/Kranochori region, at a distance of ca 7.5 km from Neolithic Avgi. Of course, smaller slabs also occur at these outcrops and we cannot exclude the possibility that the inhabitants of Neolithic Avgi have also exploited such items.

Regarding their morphology, the neolithic stone slabs tend to have a roughly rectilinear (51 items) or irregular plan shape (8 items). Few fragments, however, seem to derive from trapezoidal or even slightly ovoid slabs (2 items each). In most cases, these shapes reflect the natural forms of the lithic raw materials. Three items, however, preserve either pecking (2 items) or flaking (1 item) marks on their periphery, suggesting the alteration of the form and maybe the size reduction of the raw material. The profiles of almost all specimens (61 items) are rectangular. Items with such profiles have two opposite, broad and unrestricted faces with a flat or nearly flat configuration. In two items one of the broad faces has a slightly concave configuration, while the opposite face remains flattish, resulting in a concave/flat profile.

The broad faces of 28 items retain the natural texture and morphology of their raw materials (Fig. 19.3). On the majority of the stone slabs (35 items), however, one of the broad faces (henceforth: ventral face) had been smoothed (Fig. 19.2, 19.4). Smoothing is usually uniform, intense and continuous. It starts from the margins and expands over the whole face, being abruptly interrupted at the broken sections. In a few specimens, the smoothing is more intense, giving a slightly polished appearance to the ventral surface. The smoothing of the stone slabs is considered to be the outcome of manufacture and not of a passive abrasive use, such as abrading or polishing (cf. Mould et al 2000, 155; Tsoraki 2008, 91). If these items were used as abraders or polishers, objects of different materials (e.g. wood, bone, shell, stone) with diverse morphologies (e.g. flat, cylindrical, acute) would have been shaped over parts of the stone surfaces, at various angles and with different movements (e.g. reciprocal, rotary, random). Such uses would have led to the formation of grooves, cavities or facets over the passive surfaces of at least some specimens (cf. Bekiaris 2007, 2018; Chondrou 2011; Stroulia 2010, 2018). Moreover, it would have resulted in variances in the distribution of the abrasive wear, in the form of areas or zones within the broader surface, and perhaps in the development of linear traces running at various directions. The stone slabs from Neolithic Avgi exhibit no such evidence, even though their materials are suitable for abrading functions. On the contrary, the uniformity of the smoothing traces and their development across the whole surface of the slab indicate that the alteration of the texture of the ventral surface was a manufacturing choice. However, the purpose of the smoothing was not clear. Was it somehow associated with the function of the slabs or was it an aesthetic choice, related to the appearance of the artifacts, reflecting how they were perceived by their makers?

Another distinct feature of the stone slabs from Neolithic Avgi is their relation with fire. The majority of the stone slabs (49 items) are burnt, either totally or partially. Burning traces include areas blackened from fire, clouds, thermal cracking and thermal discoloration. They are equally encountered both in the smoothed and the unsmoothed specimens. The burning of the slabs does not seem to have been a random, accidental event, since the fire affected more intensely only one of the broad faces and the sides of the slabs. Interestingly, in the smoothed specimens the face that was usually exposed to fire was the dorsal, unsmoothed surface. The recurrent presence of burning traces on the stone slabs from Neolithic Avgi hinted at the functional relation of the majority of the specimens with fire (e.g. as cooking or heating surfaces).

Four specimens of slabs preserve traces of red pigment on their ventral faces (Fig. 19.5). It is impossible to know whether the red pigment relates to the primary use of the slabs, perhaps as surfaces for pigment processing or as palettes (cf. Schotsmans et al 2020), or whether it is associated with the recycling of the fragmented slabs. The second hypothesis is considered more plausible at least for three of the four specimens, on which the traces of red pigment are confined within the limits of the fragment and are not interrupted by breakage. Tabular stone tools with traces of red pigment on their surfaces are known in the literature under the term *palettes* (e.g. Baysal and Wright

Fig. 19.4 Fragment of a burnt stone slab. Ventral (smoothed) face, length section and dorsal face (photo: T. Bekiaris).

Fig. 19.5 Fragment of a burnt stone slab. Ventral (smoothed) face, length section and dorsal face. The ventral face preserves traces of red pigment (photo: T. Bekiaris).

2005; Mould et al 2000, 155-157; Wright et al 2013). They are usually associated with grinding and abrading tasks (Adams 2002, 146).

19.3 Raw material procurement and petrographic description

During 2015 and 2016, a thorough geo-archaeological field survey was conducted in the region of Kastoria, aiming on identifying the possible raw material sources that the inhabitants of Neolithic Avgi had exploited for the procurement of their lithic materials (Fig. 19.1; Stergiou et al 2022). Seeking to explore all the major rock formations encountered in the regional geology (Bekiaris et al 2017; Stergiou et al 2022), the field survey targeted selected areas spanning from Vernon to Grammos mountains.

The broader region of Kastoria constitutes a transitional zone between the low relief areas of the Mesohellenic Trough (MHT) and the high relief, hilly to mountainous, areas of the Pelagonian and Pindos Zones, towards east and west, respectively (Kilias et al 2015). The MHT is a sedimentary basin that was developed as the result of the complex geotectonic evolution of the Alpine Orogeny (Fig. 19.1; Kilias et al 2015). In Northern Greece, it spreads from the Greek-Albanian borders to the plain of Thessaly reaching 40 and 5 km in width and depth, respectively (Kilias et al 2015). A wide succession of sedimentary rock types (e.g. conglomerates, sandstones, marls) spanning from Middle Eocene to Middle Miocene builds up the MHT[2]. Neolithic Avgi is found on bluish to grey-bluish sandstone marls of the Ondria Formation Fm of the MHT (Fig. 19.1; Savoyat and Monopolis 1977).

2 After Kilias et al (2015) the MHT stratigraphy includes the following Formations (Fm): (i) the Middle-Upper Eocene Krania Fm, (ii) the Upper Eocene-Lower Oligocene Eptachori Fm, (iii) the Upper Oligocene-Lower Miocene Pentalofos Fm, (iv) the Lower-Middle Miocene Tsotyli Fm and (v) the Middle Miocene Ondria Fm.

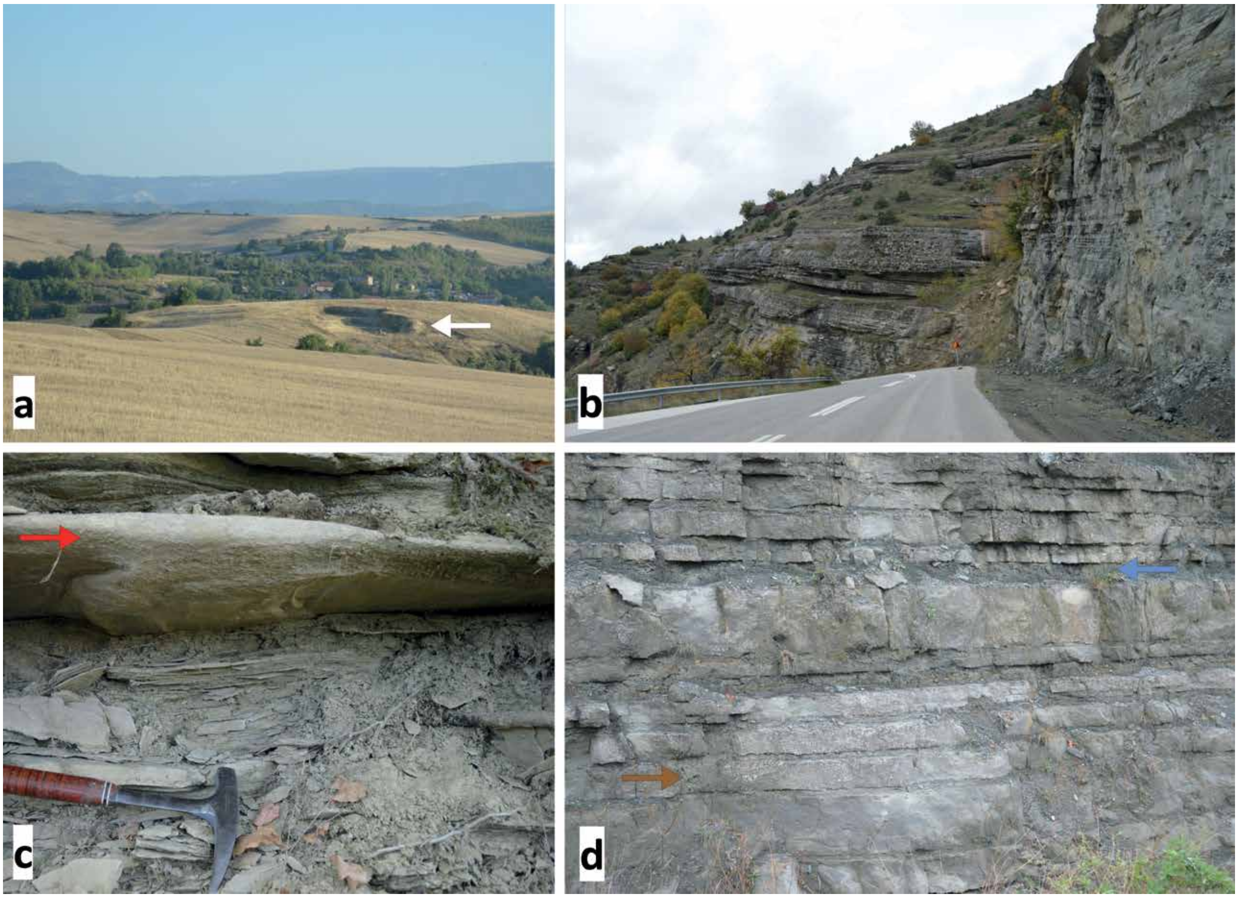
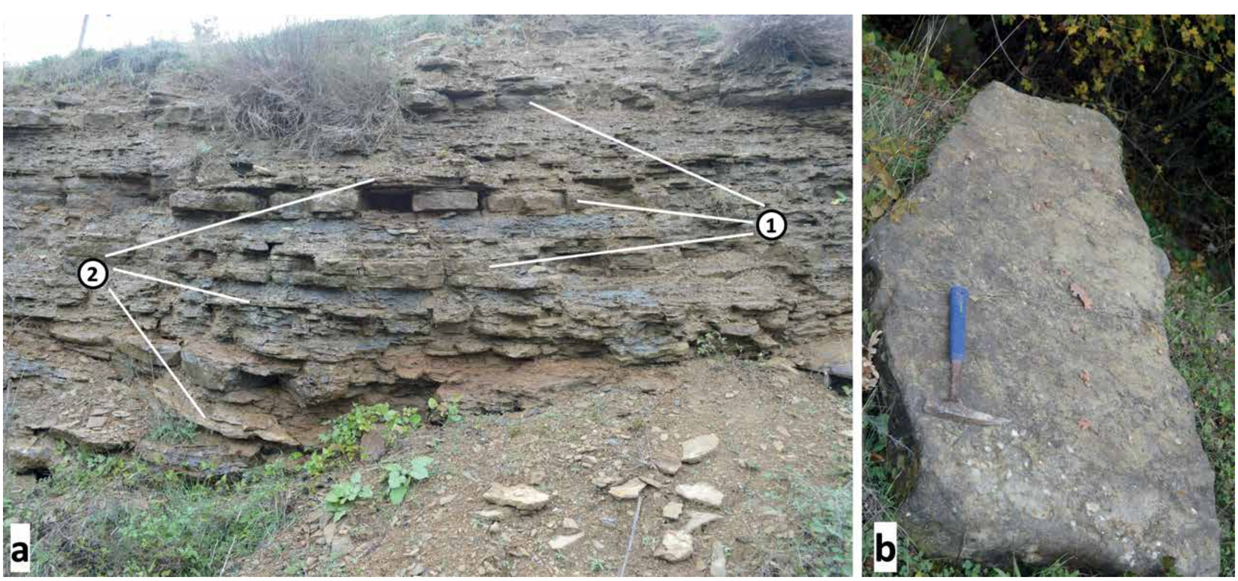


Fig. 19.6 a Smooth slopes of sandy marls found in the Ptelea area and an old quarry for the exploitation of slabs of calcareous sandstone; b Large outcrops of bedded marly sandstones and calcareous sandstones on the road to Nestorio; c A calcareous sandstone bed (up to 10 cm in thickness, red arrow) intercalated with thin beds of marly sands (less than 5 cm in thickness); d Intercalations of marls (5 to 10 cm in thickness, blue arrow) and thin-bedded, fine-grained, marly sandstones (10 to 20 cm in thickness, brown arrow) near Nestorio (photos: Ch. Stergiou).



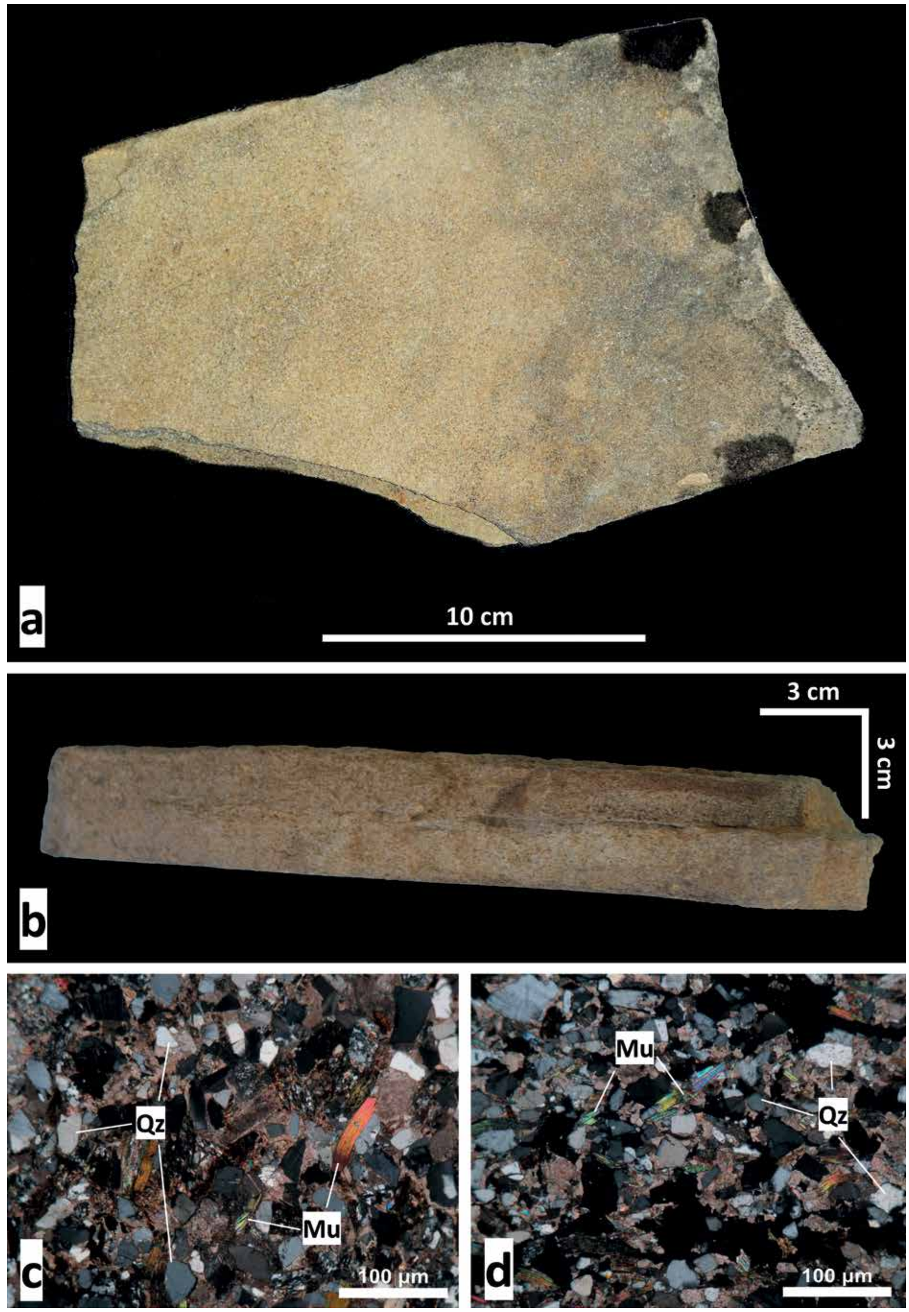


Fig. 19.8 Macroscopic (a,b) photos and photomicrographs (c,d; under cross-polarized light:+N) of geological sample and a slab (sample A0815) from Neolithic Avgi (cf. Stergiou et al 2022). a Calcareous sandstone slab collected from the Nestorio area. Its unmodified surface exhibits a distinct shiny texture due to the mica content. The blackish patches are algae; b Profile of marly sandstone slab (A0815) consisting of two thinner beds reaching approximately 1.5 cm in thickness; c Calcareous sandstone with quartz (Qz) and muscovite (Ms) set in a calcareous matrix; d. Marly sandstone with fine-grained quartz (Qtz) and muscovite (Ms) (photos: Ch. Stergiou).

Fig. 19.7 a Calcareous sandstone outcrop near Nestorio. Blue-grey marls appear as intercalations. Slabs of various sizes are found. Thicker (1) and thinner (2) beds are related to slabs of smaller and larger lengths respectively; b A large slab of calcareous sandstone more than 60 cm in length was found near Nestorio (photos: Ch. Stergiou).

Field survey indicated that the Ptelea-Nestorio district is a prominent area for the procurement of sandstone slabs (Fig. 19.1; Stergiou et al 2022). The main lithologies encountered in the Ptelea-Nestorio area include: 1) lower sandstone series and the upper conglomerate and sandstone series of Pentalofos Fm, 2) conglomerates, sandstones, marls and clastic limestones of Tsotyli Fm, and 3) sandy marls of the Ondria Fm (Savoyat and Monopolis 1977). The Pentalofos series include cohesive marls and fine-grained marly sandstones, the Tsotyli Fm comprise marly sandstones and calcareous sandstones, while the Ondria Fm locally exhibits more cohesive and bedded marly sands, which are intercalated with bedded calcareous sandstones.

Low-angle smooth slopes of sandy marls (<5 cm in thickness when bedded) and bedded, fine-grained calcareous sandstones characterize the Ptelea area (see Fig. 19.1), while major steep outcrops of thin-bedded, fine-grained, marly sandstones and calcareous sandstones dominate the landscape towards the Nestorio area (Fig. 19.6a, b). Thin-bedded sandstones do not exceed 10 cm in thickness (Fig. 19.6c, d; Fig. 19.7). Tabular sandstone pieces can be easily detached from these outcrops, without the need of any tools. In their natural form, these slabs are usually up to 40 cm in length, but larger specimens can also be found (Fig. 19.6a, b; Fig. 19.7).

The macroscopic and microscopic study of selected samples (Stergiou et al 2022) revealed significant similarities between the archaeological and geological material in respect to the rock types, mineralogical composition and textural characteristics (Fig. 19.8a, b). Furthermore, the optical microscopy study revealed the textural and mineralogical aspects of the fine-grained, calcareous and marly sandstones. Calcareous sandstones display a coarse-grained texture and consist of quartz (30 to 500 μm in size), plagioclase, muscovite, and biotite, well cemented within a calcareous matrix (Fig. 19.8c; Stergiou et al 2022). Marly sandstones exhibit a fine-grained equigranular texture and comprise quartz (rounded grains, <50 μm in size), calcite, plagioclase, biotite, and muscovite (Fig. 19.8d; Stergiou et al 2022).

19.4 Contexts of use and deposition

The majority of the AVGI I and AVGI II stone slabs were located in open-air spaces (for the detailed spatial distribution of the slabs see Bekiaris 2018). Only a slab from AVGI I can be associated with a house (Building 5). In the open-air spaces, the stone slabs are usually found in proximity to thermal structures and cooking locales (Kalogiropoulou 2013), or areas with ash lenses that the micromorphological study has identified as open-air hearths (cf. Koromila 2015). The distribution of the stone slabs in the open areas matches, to some extent, the distribution of another group of macrolithics that is associated with fire-related practices: the burnt limestone pebbles (cf. Bekiaris 2018, 93). The pebbles, heavily deformed by fire, were used as the underlays of hearths with polished and smoothened heating floor surfaces and thus their presence could be considered as indirect evidence for the existence of such features. Pebble-underlaid hearths could have supported various cooking-related activities, such as boiling, grilling, smoking and parching (cf. Kalogiropoulou 2013).

Ten stone slabs derive from the AVGI III pits, while three were found within other subterranean features (e.g. ditches, post-holes) ascribed to the same stratigraphic phase. These cuttings, particularly the pits, contained a diverse range of deposited material, among which both refuse and several intact and apparently still functional artifacts (cf. Stratouli et al 2020). The filling of the pits is perceived as the outcome of selective depositional practices (cf. Hondroyianni-Metoki 2009; Stratouli et al 2014, 2020), often accomplished in the course of multiple episodes (Stratouli et al 2014).

19.5 Πιτούλκες *(pitoulkes)* and πιτουλνίτσες *(pitoulnitses)*: The use of stone slabs for cooking in the local tradition of Kastoria

The stone slabs from Neolithic Avgi are certainly among the most "enigmatic" artifacts of the macrolithic assemblage, in terms of comprehending the possible use(s) and interpreting some of their technological attributes, such as the smoothening of their surfaces. Surprisingly, for some of the locals, the interpretation of these artifacts was pretty straightforward, since they instantly identified them as fragments of πιτουλνίτσες (*pitoulnitses*), i.e. cooking slabs that were used until recently in the broader region of Kastoria for baking thin pies, the so-called πιτούλκες (*pitoulkes*). In the village of Nestorio, the memories of this tradition are still vivid, since some families have such cooking slabs in their possession, and use them occasionally to make pies. We had the opportunity to visit the family of the late Vasso Liousi, who kindly used her *pitoulnitsa* to prepare some delicious pies, and shared some interesting stories regarding these traditional cooking slabs.

Pitoulnitses are perceived by their owners as valuable heirlooms, associated with traditions and knowledge that were lost in time, thus making these artifacts irreplaceable. In past years, most families in Nestorio owned a cooking slab. The baking of *pitoulkes* on these slabs was not a mundane, everyday activity, but rather a special event, performed only by the women of the village on special occasions, such as to welcome the birth of a child. Nowadays, this tradition has faded almost completely. Only a limited number of cooking slabs survive in the village, while the baking of pies has been detached from its festive/symbolic context and occurs only to suffice the household's needs.

Regarding the origins of the stone slabs, both Vasso and her son Paschalis told us that they could be found locally, but the exact locations of their outcrops are unknown. In the past, these slabs were regularly extracted to be used as roof tiles, an architectural tradition, commonly encountered in Nestorio and several other villages in the broader region. Our informants have stressed, however, that not every slab is suitable to be used as a *pitoulnitsa* and that only the elderly people knew how to recognize the proper slabs. The Liousis family had acquired their

Fig. 19.9 a-d The use of a traditional cooking slab (*πιτουλνίτσα*) from Nestorio (property of the late Vasso Liousi) for the baking of thin pies (*πιτούλκες*). The stone slab is heavily affected by the fire and has a transversal crack on the ventral (smoothed) surface. On the same surface, five small cavities have been formed by the long-term baking of pies on the same spots of the slab (photos: T. Bekiaris and N. Katsikaridis).

cooking slab from the roof of a demolished old building. The narration of the events, although a little exaggerated, is indicative of the importance and rarity that the locals want to ascribe to these artifacts:

> *The old man was standing quietly, watching the demolition of the barn. We had already removed all the stone slabs from the collapsed roof and had put them by the pavement, waiting to be picked up by the truck. I approached and asked the old man whether he could recognize a pitoulnitsa among the roof tiles. He didn't respond at once but kept staring at the debris. Later, he silently approached the slabs and tapped one of them with his cane…*

Vasso's *pitoulnitsa* was made of fine-grained sandstone, which looked identical with the raw material of the neolithic specimens (Fig. 19.9a). The slab was quite large, measuring circa 60 cm in length, 30 cm in width, and 3 cm in thickness. It had a rectilinear plan and a concave/flat section (Fig. 19.9b). As expected, its dorsal face and sides were heavily affected by the fire. Interestingly, the ventral face of the slab was heavily smoothed, bearing a close resemblance to the neolithic artifacts. Vasso told us that the smoothing of the face occurred before using these slabs for the first time. It was a necessary manufacturing step, in order to tighten their texture and avoid the production of dust and grit that would contaminate the foodstuffs. Smoothing was achieved by rubbing the slab's surface with salt. According to Vasso, another crucial step before the initial use of these slabs was to test their thermal resistance by firing them. The process initiated with the progressive heating of the slab, by placing it next to the fire. Direct exposure to high temperatures was avoided since it could destroy the slab. After its heating, the slab was placed directly on an open fire. During this procedure, the slab would normally crack, but not break, an indication that it is suitable to be used for cooking. Indeed, Vasso's *pitoulnitsa* had a crack running transversally to the middle of the ventral face (Fig. 19.9c).

Another interesting feature was that the slab had five small and shallow cavities on its ventral smoothed face. This was an *a posteriori* attribute, created by the long-term baking of pies in the same spots of the surface and by the circular movement of the wooden ladle when rolling out the dough (Fig. 19.9c, d).

The *pitoulkes* we tasted were very thin pies, similar to the French crepes (Fig. 19.9d). Their dough was made only with water and flour, with the optional addition of salt. When baked, the pies were served with butter, fruits and/or nuts. Vasso also used the slab to bake small bread, using the leftovers of the same mixture. After the use of the slab, she covered its surface with ash from the burnt firewood to clean the cooking surface of the burnt dough.

19.6 The tradition of cooking with stone slabs in other parts of Greece

The practice of cooking with stone slabs is not confined within the region of Kastoria. Similar customs are documented in several regions of both the Greek mainland and the Aegean Islands, pointing to the existence of a wide-spread tradition. In most regions, the custom has a strong religious/ritual character since it is associated with Christian feast days, such as Christmas or the Epiphany.

In Epirus, in several villages used to bake pies, known as "The swaddling clothes of Christ" (τα σπάργανα του Χριστού)[3] on Christmas Eve, using flat stone slabs they called "blackened slabs" (μαυρόπλακες in Greek, Epirotic Estia 51, 35). The pies were made again only with flour, water and salt, and were consumed on Christmas Day with nuts, honey, sugar, molasses, or other additives. The sizes of the μαυρόπλακες *(mavroplakes)* were usually 40x40 cm and their thickness roughly 3.5 cm. Their raw material might originate from sandstones related to thin-bedded flysch outcrops of the Ionian Zone. Field observations in the broader area of Pramanta and Agnanta revealed several such outcrops (Stergiou, pers. observ.). The Eocene to the Lower Miocene flysch in this area consists of dark in color, calcareous sandstone beds (approximately 2 to 15 cm in thickness), which are intercalated with blue-grayish marls (up to 2 cm in thickness; Aubouin 1961; Savoyat et al 1970). Before their use, the people cleaned the slabs from any unwanted remnants that could contaminate the pies, by placing them in a container full of water for at least ten days or by covering them with ash (Epirotic Estia 51, 35). The heating of the slabs was again progressive to avoid cracking and to increase their thermal resistance. At first, the slabs were covered with hot coals and ashes, and on the next day, they were laid directly on a fire. After their use, the slabs were covered with a swaddling cloth, which was tied in the shape of a cross. Their owners stored the slabs, keeping them as heirlooms, until next Christmas.

In the Aegean Islands, specifically in the Islands of Limnos, Skyros, and Kos the traditional custom of baking pies, called μαρμαρίτες (*marmarites*) or φωτόπιτες (*fotopites*), on stone slabs is associated with the Christian feast day of the Epiphany (Imellos and Polymerou-Kamilaki 1983). Marble slabs, deriving from destroyed stone ovens, were regularly used as expedient cooking surfaces in these islands. The circular shape of the pies was perceived as a symbolic reference to the sun. On Limnos, the pies were made a day after the Epiphany and holy water was used in the mixture of the dough. In these islands, several rock types occur in thin-bedded outcrops that could be used as cooking surfaces. On Limnos Island, the Eocene-Oligocene Lower Unit comprises thin-bedded sandstones that are intercalated with marls (Roussos 1987). On Kos Island, thin-bedded outcrops are associated with the Lower Paleocene flysch, the Middle to Upper Cretaceous Limestone Sequence, and the Mesozoic thin- to medium-bedded calcitic marbles (Triantafillis 1986, Triantafillis and Dalampakis 1989). On Kos Island, the Lower Miocene sandstones and shales, the Eocene flysch of the Eastern Kos Unit, and the Mesozoic to Eocene limestones could be related to thin-bedded outcrops.

Similar customs are also reported from Central Macedonia and Thrace (e.g. Olmpasali 2020, 80). In these regions, the stone slab was a traditional, circular, black cooking utensil, known as σατσί (*satsi*). Its diameter was ca 40 cm while its thickness ranged from 2-3 cm. The custom of baking pies was performed at the feast day of the Holy Forty on 9th March. In some areas (e.g. Rhodope) they cooked the pies in order to feed and honor the shepherds that were in the region grazing their herds.

19.7 Experimenting with the manufacture and use of stone slabs

In the course of an educational program called "Learning about food preparation at the Neolithic Settlement of Avgi" (cf. Stratouli et al 2013) we had the opportunity to conduct small-scale experiments on the manufacture and use of cooking stone slabs. After acquiring the necessary sandstone slabs[4] (Fig. 19.10a), we attempted to smooth

3 At some villages the custom is known as "The swaddling clothes of Holy Mary" (τα σπάργανα της Παναγίας).

4 Ten slabs were collected directly from the bedrocks at the Ptelea-Kranochori region. No mechanical means were used for the extraction of the slabs, since it was easy to remove them from the weathered bedrock. The collected slabs had an average length of 50 cm, an average width of 30 cm and an average thickness of 1-2 cm.

Fig. 19.10 The experimental manufacture of cooking slabs. a Sandstone slabs collected for the small-scale experiments; b Peripheral shaping of the slabs through flaking and pecking with the use of hammerstones made from igneous rocks; c smoothing a fragment of a sandstone slab through rubbing it on a sandstone cobble with salt as an abrasive agent and the use of water; d smoothing a sandstone slab by shaping a serpentinite edge tool over its surface with sand as an abrasive agent and the use of running water (photos: T. Bekiaris, N. Katsikaridis, Ch. Stergiou).

the ventral surfaces of two random specimens. Since smoothing the whole surface of the stone slab was a time-consuming process, we chose to experiment on smaller pieces, that we have detached from the selected sandstone slabs. One piece was smoothed by abrading it with a sandstone cobble, using salt as an intermediate abrasive agent (Fig. 19.10c). Water was also applied regularly to wash away the grit produced during the abrading. The result was rather sufficient (the irregularities in the topography of the passive stone surface were elevated and smoothed and the overall face was highly polished in less than an hour), but the process certainly demanded time and effort, at least for inexperienced manufacturers such as us, especially if we had to polish the surface of an intact slab. Another sandstone piece was smoothed by shaping a serpentinite edge tool directly on its surface (Fig. 19.10d). We have tried salt again as an abrasive agent, but sand proved to be much more effective both for shaping the edge tool and the surface of the slab. Running water was essential in the process to reduce the heating produced by friction and wash away the tiny stone particles that occurred, a practice well known from the production of edge tools (cf. Nami 1984, 104; Stroulia 2010, 69). Even though this attempt has confirmed the abrasive capacity of the sandstone slabs, we found that it would be rather impractical for the Neolithic people to use large stone slabs for shaping such small or medium sized tools. Besides smoothing, we have also tried to shape the periphery of two other intact slabs through direct and indirect percussion (Fig. 19.10b). Gabbro hammerstones of types resembling those encountered in the macrolithic assemblage of Neolithic Avgi (cf. Bekiaris 2018) were employed in this process. Indirect percussion proved to be more suitable for the thin (<3 cm) stone slabs since direct percussion caused extended cracks and damaged the surfaces.

The next step was to test the thermal resistance of six unsmoothed slabs through heating, firing and cooking (Fig. 19.11a, b). Apparently, not all of them survived these steps. Some thinner specimens (ca 1 cm in thickness) broke into several pieces during heating and firing. Other slabs, even though they didn't break during the first two steps, they proved to be ill-suited for cooking since for some reason they couldn't be

Fig. 19.11 The experimental use of stone slabs. a-b The progressive heating of an unsmoothed experimental stone slab; c its unsuccessful use for baking pies; d The successful use of a smoothed stone slab for baking pies (photos: T. Bekiaris, N. Katsikaridis).

heated enough to bake the pastry (Fig. 19.11c). In the end, only two of the six slabs seemed to be effective for cooking. The ventral surfaces of these two slabs were then smoothed with mechanical means. Both slabs were repeatedly used in the context of educational activities for baking pies (Fig. 19.11d). Besides *pitoulkes*, we have used them effectively for roasting thin slices of pork meat, the cooking of vegetables, as well as for cooking bulgur within a modern clay pot that was placed on the surface of the cooking slab (cf. Stratouli et al 2013).

19.8 Discussion and conclusion

Assessing with accuracy the use(s) of the stone slabs from Neolithic Avgi constitutes a rather challenging endeavor that would require further investigation in the fields of microscopy, residue and starch analysis, thermal properties and experimental replication. The current state of research, however, provided sufficient evidence to support a discussion regarding the possible use(s) of these technological products.

The repeated presence of burning traces, mostly on the dorsal faces and on the sides of these implements, clearly points towards their association with fire-related practices. Their use as cooking surfaces, for roasting, parching and baking of various foodstuffs constitutes a plausible interpretation, based on ethnographic observations and our small-scale experimentation. Besides, the involvement of macrolithics in neolithic cooking practices is not entirely unknown in the literature. A similar hypothesis has been also made by Tsoraki (2008, 107-108), who suspects that some grinding slabs from Late Neolithic Makriyalos in Pieria were reused as cooking surfaces, resulting to the presence of burning traces on their surfaces. Furthermore, Baysal and Wright (2005) mention that macrolithic fragments were often placed inside ovens at neolithic Çatalhöyük in order to distribute heat while cooking, a practice which is also well-documented ethnographically (Baysal and Wright 2005, 315).

At Neolithic Avgi the functional correlation of the stone slabs with fire activities is further supported by their spatial distribution. Stone slabs are commonly encountered in the vicinity of open-air cooking installations or near open fires (Bekiaris 2018). In addition to that, their distribution within these spatial contexts matches that of the burnt limestone pebbles, which were used as the underlays for clay heating floors of hearths (Bekiaris 2018, 93; Kalogiropoulou 2013, 2020). Even though there is no direct evidence for the combined use of the stone slabs and the pebble-underlaid hearths, the possibility that both acted in a more or less similar way, as heating surfaces for the direct or indirect processing of foodstuffs cannot be excluded.

The association of the neolithic stone slabs with fire-related practices is further supported by the thermal properties (i.e. thermal conductivity, diffusivity and resistance/endurance) of their raw material (cf. Stergiou et al 2022). The preference of fine-grained sandstones for the production of these artifacts, over other rocks (e.g. schists), could indicate that this choice was defined by the properties of the lithic material and their association with the intended use of the implements, a pattern observed in many other macrolithic categories from Neolithic Avgi (cf. Bekiaris et al 2017; Bekiaris 2018; Stergiou et al 2022).

Different varieties of sandstone exhibit a wide range of thermal properties, as a result of variations in mineral composition and texture (Koňáková et al 2013; Török and Hajpál 2005). Fine-grained sandstones, as well as other fine-grained sedimentary rocks, such as siltstones and marlstones, enriched in quartz can be related to significant thermal properties (Labus and Labus 2018), thus being suitable for a use that would involve their exposure to fire. The thermal resistance of sandstones depends on the amount and mineralogy of matrix, on granularity and pore fluids (e.g. water, air) found in the intragranular space (Robertson 1988; Török and Hajpál 2005). According to Török and Hajpál (2005) the mineral composition and the physical properties of calcareous and marly sandstones, such as the ones used for the slabs both in the neolithic and modern times, are heavily modified when directly heated. For instance, at temperatures between 450°-750°C clay minerals, such as smectite and illite group minerals disintegrate, resulting to the mechanical destabilization of the matrix (Török and Hajpál 2005). Therefore, the cooking fires to which the slabs had been exposed should not have exceeded 350-450 °C. These properties could explain the progressive heating of the modern stone slab used at Nestorio before its first exposure to direct fire. This thermal treatment was essential to test the thermal endurance of the slab, each time they wanted to cook, but also resulted in its mineralogical and textural modification and probably in the removal of any pore fluids that would enhance its thermal resistance.

The functional capacity of the sandstone slabs for cooking practices is further attested by their traditional use as cooking utensils in the region of Kastoria. The slab that we had the opportunity to observe in Nestorio shares several similarities with the Neolithic specimens, in terms of raw material, size, morphology, location of the burning traces and manufacture attributes, specifically the smoothing of the ventral surface. Several other examples of stone slabs used as cooking surfaces are reported from various regions in Greece, each associated with specific culinary traditions, rituals and customs.

Of course, the employment of stone slabs in cooking practices is not confined to the Greek cases. The use of stone slabs as cooking surfaces is a worldwide, cross-cultural phenomenon attested by several archaeological and ethnoarchaeological examples. The cooking slabs, known in different parts of the world as *griddles*[5] (e.g. Adams 2002, 229; Lyon and D' Andrea 2003; Jeannotte et al 2012; Admiraal et al 2018) were placed over open fires, pit fires or thermal structures and were used to bake various types of flatbreads, loafs, tortillas, cakes, as well as foodstuffs made from aquatic resources, as indicated by lipid residue analysis (Admiraal et al 2018). Adams (2002, 229-230) mentions a special group of cooking slabs, called *pikistones,* used until today by the Puebloan people in America to make thin corn-tortillas, which bear a great resemblance with the slabs from Neolithic Avgi and Nestorio. *Pikistones* are made of fine-grained sandstone, which can only be obtained by few traditional quarries (Woodbury 1954, 176-177). The procurement of a new raw material for the making of a pikistone is a ritualized act, while their manufacture is a delicate process which requires special skills. Thus, they are perceived as valuable commodities or heirlooms among the modern Puebloans, as has been observed for the Kastoria cases. *Pikistones* have also smoothed baking surfaces, created both by grinding and oiling to prevent the sticking of the dough to the stone.

Certainly, it would be overly simplistic to draw a direct link between the ethnographic examples and the Neolithic past, in an attempt to define the function of these implements. However, both the experience of observing the use of a traditional stone cooking utensil in Nestorio and the cases encountered in the literature can significantly broaden our perspectives on how such items could have been manipulated and used during the Neolithic.

To conclude, it would not be far-fetched to hypothesize that some of the neolithic slabs could have served as cooking surfaces for the roasting of seeds, nuts and plant

5 Griddles made of clay are also known in the literature (e.g. Ciofalo et al 2019; Lyon and D' Andrea 2003).

foods, the baking of dough, meat or fish, or the heating and boiling of solid food and liquids (foods or medicines) within containers that would have been placed on the slabs, to avoid their direct contact with fire. Some stone slabs could have also acted in combination with the firing installations for temporarily closing the entrances and orifices of the ovens to control the temperature as desired (see Kalogiropoulou 2013, 121). Further evidence for such practices is attested in Neolithic Avgi by a large burnt sandstone cobble, which was found next to the entrance of an oven, perhaps used for blocking the opening in order to increase the temperature inside the vault[6] (Bekiaris 2018, 349; Kalogiropoulou 2013, 121). Moreover, some of these slabs might have been used as heating surfaces for the processing of pigments or other substances, while after their breakage they could have served as palettes, weights or even as lids for containers.

Systematic research on the macrolithic industries from several neolithic sites in Northern Greece, ongoing over the past years, has significantly contributed towards the recognition of artifact categories that were previously unknown in the relevant literature. The stone slabs associated with fire-related practices from Neolithic Avgi that were presented in this study constitutes such an example. Similar artifacts have never before been recognized as an individual technological group, intentionally manufacture maybe for cooking purposes. It is possible that such implements exist in the macrolithic assemblages of other neolithic communities, but have been assigned to other macrolithic groups, such as grinding tools, abraders, palettes, etc. The stone slabs we have investigated might have constituted a distinct material element, associated with the local technological tradition and the identity of Neolithic Avgi. We hope that our research presented here will permit the identification of similar tools at other sites and contribute towards the exploration of cooking variability in the Greek Neolithic.

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6 Limestone slabs, some of which burnt, were unearthed next to nine hearths In the Neolithic site of Sotira in Cyprus. Dikaios assumes that these features were used to control the fires in the hearth vaults (Dikaios 1961, 159).

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Chapter 20

Grinding systems as cultural markers at the turn of the 6th millennium BC in north-western continental Europe

Caroline Hamon

Abstract

By the last third of the 6th mill BC, the first Neolithic pioneers had introduced sedentism and novel agricultural systems to the north-western part of the European continent. The intensive consumption of certain foods, in particular cereals, by the first agricultural populations was accompanied by the unprecedented use of grinding systems for food preparation. The general overview presented here of the grinding technologies used within the Rhine and Seine regions between 5300 and 4700 BC allows us to define standards, which may be understood as cultural markers. Found exclusively in domestic contexts, these grinding tools were subject to deliberate hoarding and breakage practices which illustrate their particular status. Their long use-lives, illustrated by morphological distortion and intense traces of manipulation, also suggest their central role in daily tasks. Hard quarzitic sandstone was sought out, sometimes from distant sources, in order to produce good quality grinding stones. The existence of typological standards and of shaping stages requiring a high degree of effort, time and know-how suggest that specific apprenticeship networks existed within LBK populations. These grinding tools all belong to the reciprocal motion category, to the exclusion of other types of grinding systems. Two main types of grinding tools can be found, namely those used with short "bread-shaped" grinders or with long overlapping grinders. Use-wear analysis highlights the specialisation of grinding tools at different stages of cereal transformation, while phytoliths and starch grain analysis suggest that other plants were prepared or mixed on these grinding slabs. Finally, regional variations and chronological evolutions of these grinding tool types within our study area indicate that these tools were an inheritance from the LBK of Central Europe and that, by the end of the sequence they had undergone a certain degree of innovation as their use spread westwards.

Keywords: *grinding technologies, Linearbandkeramik, north-western Europe, cultural traditions, innovations.*

20.1 Introduction

By the last third of the 6th mill BC, the first Neolithic pioneers introduced sedentism and novel agricultural systems to the north-western part of the European continent. The increasing selection of certain plant species, followed by the intensification of their cultivation, implies deep changes in the way plants were processed and prepared. The

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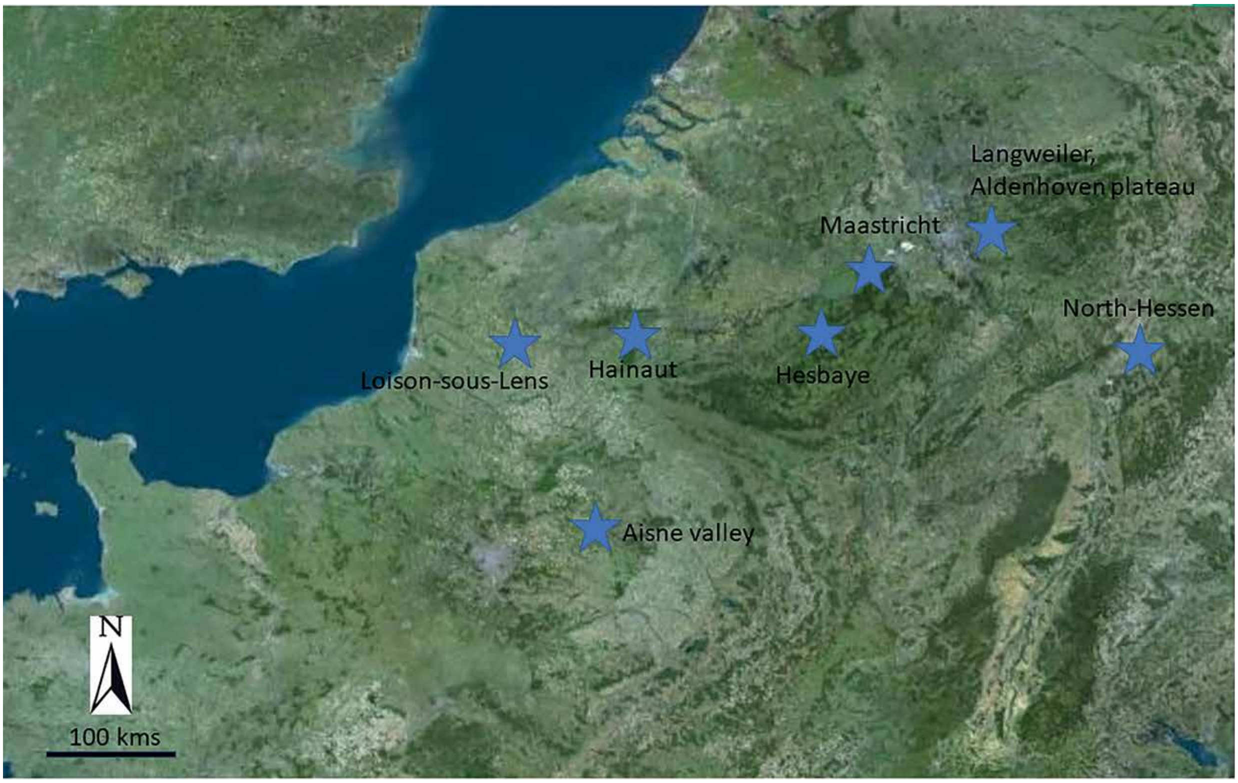

Fig. 20.1 Map of the main region and sites cited.

intensive consumption of certain foods, in particular cereals, was accompanied by the unprecedented use of grinding systems. This marked increase in the use of grinding techniques in many aspects of daily activity has to be directly linked to the high level of sedentary life-style and the demographic expansion which characterized the neolithization process in these regions.

In this paper, we propose a general overview of the grinding technologies used within the Rhine and Seine regions between 5300 and 4700 BC. The dataset covers the entire LBK sequence in the region, from the middle LBK to post-LBK (in particular the Blicquy-Villeneuve-Saint-Germain culture). We explore the common technological background and shared heritage in LBK contexts, and track some of the innovations within post-LBK groups located at the western margins of the LBK expansion area. Our knowledge of grinding technologies from north-western continental Europe is based on a number of different studies (Fig. 20.1): i) in the Weser, Rhineland and northern Hesse regions of north-western Germany (Graefe 2004, 2008; Ramminger 2007; Zimmermann 1988), ii) in the region of Maastricht in southern Holland (Moddermann 1970; Verbaas and van Gijn 2007; Verbaas 2014), iii) in Hesbaye (Hamon and Goemaere 2007; Jadin 2003), Luxembourg (Hauzeur 2006) and Hainaut (Constantin et al 1978; Hamon 2008b) in southern Belgium and iv) in the Paris Basin (Hamon 2006; Praud et al 2018; Hamon et al 2017).

Emblematic of important food practices, grinding tools are of particular interest for the analysis of transitional and abrupt mutation phases of the early part of the Neolithic. Consequently, the study of grinding implements in the context of neolithization provides key information regarding the deep changes that took place in food production and consumption habits, as well as in other fields of the technical sphere.

20.2 Grinding equipment at the centre of domestic activities

The production and use of grinding tools in LBK and post – LBK contexts are deeply connected to the domestic space and the household. The domestic space is well defined by the typical tripartite houses built of wood and daub, and their associated lateral waste pits where all archaeological material was found (Moddermann 1970; Allard et al 2013).

First of all, many evidence indicate that the production of grinding tools was, at least in part, carried out within the domestic space. Occasional roughouts of querns and grinders, as well as a variable quantity of shaping and rejuvenation flakes are regularly found in domestic pits (Zimmermann 1988; Billard et al 2014). In the late LBK site of Cuiry-les-Chaudardes, one house per stage of development of the village yields most of the production waste (Hamon 2006). This would suggest the existence of specific apprenticeship networks and knowhow regarding the extraction and shaping processes.

In the majority of LBK contexts, most of the grinding tools display very high rate of fragmentation prior to their final disposal in waste pits. This high degree of fragmentation attests to specific practices linked to the abandonment of grinding tools whose use-lives are assumed to have been particularly long, perhaps spanning several decades. Here, we are probably looking at voluntary breakage, with specific breaking techniques being used, probably on specific occasions. Verbaas and van Gijn (2007) also suggested that "the querns had to be destroyed, had to die so to speak", suggesting a more symbolic treatment of grinding tools after use.

Despite being found in secondary contexts, three main areas of concentration are observable within the waste pits. The back of the house seems to have been at least partly used as a storage area. Concentrations of complete grinding tools have been found at the back of two BVSG houses in Jablines, where soils were exceptionally preserved; this location indicates that the tools were stored either just outside or within the rear part of the houses (Hamon 2006). One hoard has also been found in a pit at the back of a long house in Berry-au-Bac, where 3 querns and 4 grinders were deposited in a storage position (Hamon 2020). Concentrations of grinding tools also suggests use at the front entrance, possibly for winnowing or de-husking tasks, and at the centre of the house where most of the domestic activities, including food preparation, are assumed to have taken place (Hamon 2006).

The number of querns and grinders per house varies, and is suggested to reflect the number of inhabitants to feed, and of women in charge of food preparation. Different estimations have been proposed on the basis of ethnographic comparisons, demographic models and estimations of the average lifetime of each house. Considering an assumed life-span of ca 30 years for LBK houses, Weiner and Schachlich (2006, 208) proposed that adult female members of an LBK family would have needed 5 bottom stones and 10 rubbers over the life-span of a house. Ramminger (2007) suggested that "a six persons family of one house generation would have needed 8,3 rubber stones and 4,2 querns, postulating an operating life expectancy of 3 and 6 years respectively". These average numbers fit well with similar observations in the Aisne valley (Allard et al 2013).

The structuring role of grinding activities within LBK domestic space has also been highlighted in a wider economic perspective. Their relative quantities per house unit seem to be directly related to the the level of agricultural and economical maturity of each household in the village. As a matter of fact, the consumption of cereals by a household would more or less depend directly on its capacity for agricultural production, including animal breeding and cultivation (Hachem and Hamon 2014; Gomart et al 2015).

20.3 LBK grinding systems and plant processing

In the region located between the Rhine and the Seine basins, the ever-growing number of grinding tool studies provides a general overview of the characteristics of the grinding systems used by LBK and post-LBK populations.

20.3.1 Optimizing the grinding process: mechanical properties and shaping

Sandstone was the raw material of choice of LBK populations throughout Europe. In north-western Europe, LBK people preferred hard, quarzitic, well-cemented, round-grained sandstone: this type of rock is particularly hard and ensured that the querns had a long use-life and good abrasive properties (Verbaas 2014; Hamon and Fronteau 2018; Zimmermann 1988). More occasionally, in the vicinity of volcanic massifs, granites (Armorican Massif, Munster Land) and basalts (Eifel, Vosges) were also exploited to produce grinding tools, especially when their granularity and natural vesicularity lent themselves to this use.

These two types of raw material were exploited alternately or in parallel. Where possible, the collection of blocks from riverbeds predominated to the west of the Rhine (Verbaas and van Gijn 2007; Hamon 2006). However, in various other regions, the quadrangular shape of most of the querns suggests that sandstone slabs were extracted from outcrops (Praud et al 2018; Constantin et al 1978). Zimmermann (1988) suggested that this was the source of raw material for the sites of the Aldenhoven plateau, on the basis of the large dimensions of the grinding tools which do not match the sizes of blocks available in local riverbeds. For north Hesse, Graefe (2008) identified the exploitation of Triassic sandstones, breccias and greywackes and discussed the possibility that they were extracted from quarries located at least 50 km from the sites. This average distance was also suggested in the context of Langweiler and the Rhineland (Weiner and Schalich 2006). Possible exchange networks have also been proposed, between regions with suitable rock supplies and others located in less well-endowed areas (Ramminger 2007; Hamon and Fronteau 2018).

One of the main characteristics of LBK grinding tools relative to other European Neolithic contexts is their high degree of shaping (Fig. 20.2). In the Maastricht region, extracted blocks underwent a greater degree of modification than blocks selected and collected from the riverbed whose dimensions and morphology were closer to those of the intended final product (Verbaas 2014).

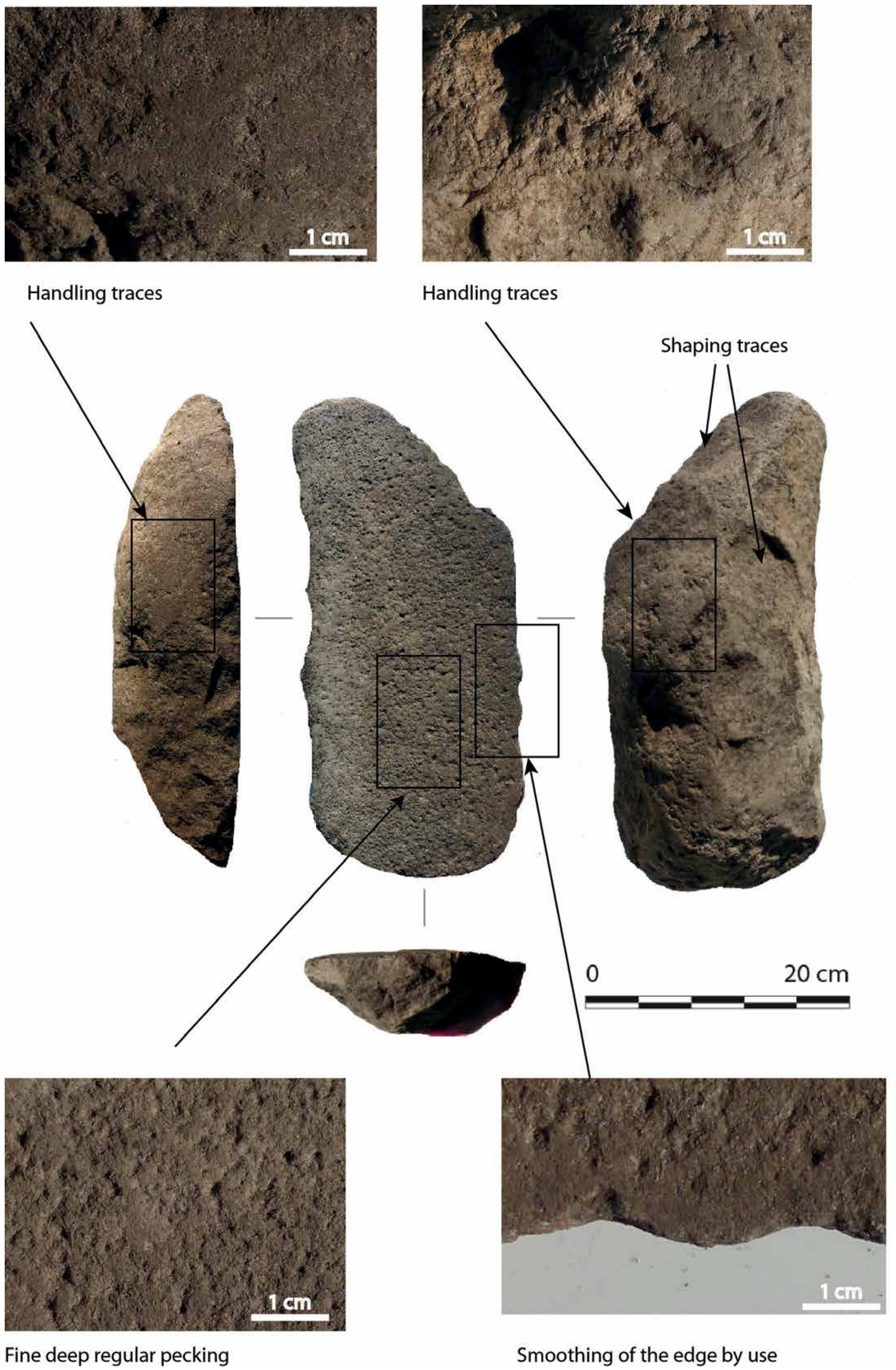

Fig. 20.2 Traces of shaping and use on grinder no 6 from the LBK grinding tool hoard from Berry-au-Bac (Aisne Valley). Traces of handling. a fingertips; b palm; c flaking of the sides and back; d fine regular pecking of the active surface; e smoothing of the edge by stone-against-stone contact.

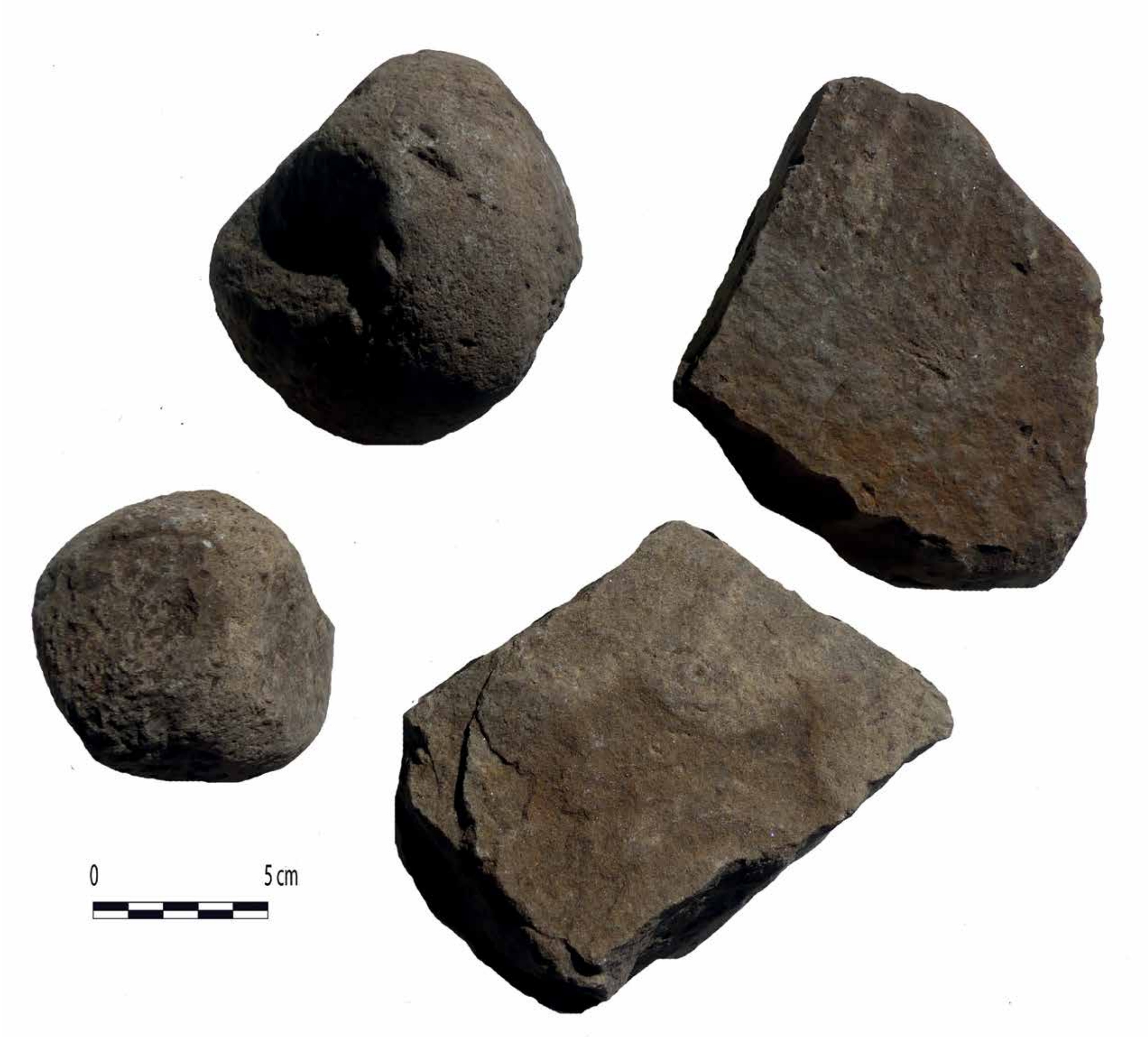

Fig. 20.3 Association of fragments of sandstone grinder roughouts and hammerstones found in a pit on the LBK site of Chassemy le Grand Horle (Aisne valley).

Generally, the shaping of their sides and back seems to follow a specific sequence, in order to respect certain standards (Verbaas 2014; Hamon and Goemaere 2007). A great deal of time-consuming effort was invested in their shaping to the extent that the different stages and traces of initial shaping (especially flake removals) are completely erased by fine pecking of the exposed surfaces.

The initial pecking of the grinding surface generally produced very deep impacts, sometimes with linear orientation. The tools used for this particular stage of preparation are unknown, although some spheroid hammerstones have been found with grinder roughouts (Fig. 20.3), and reused cores with traces of intense percussion have been tested experimentally (Verbaas and van Gijn 2007). The rejuvenation of the surfaces can be complete or partial, and be accompanied or not by reshaping of other parts of the tools, especially the sides and ends to ensure the fluid action of the grinder.

20.3.2 Exclusively reciprocal grinding systems?

Contrary to other Neolithic contexts from the Near-East to the western Mediterranean, no circular grinding tools and very few pounding tools were used in the LBK culture. The dominant and standard grinding system involves querns and grinders that were operated using a rectilinear motion (Fig. 20.4). Contrary to circular grinding, which requires pressure mainly from the hand and arm, reciprocal grinding systems implies greater mechanical pressure as the complete upper part of the body is mobilized. In this sense, reciprocal grinding systems would have been more efficient for grinding hard materials and/or large quantities of matter.

In any case, traces of manipulation at the back of querns and grinders attest to their intensive use. In general, the shapes of the querns would have required some form of installation either using temporary stabilising stones,

Fig. 20.4 Example of the use of reciprocal grinding system by a Minyanka woman (Mali) (photo: C. Hamon and V. Le Gall).

which would have allowed the quern to be easily moved and stored elsewhere, or perhaps by setting it within a permanent frame of wood or daub. It has also been suggested that querns were placed on hides or leather on the basis of the use-wear traces (Verbaas and van Gijn 2007). Such an arrangement would have protected the quern from the soil and would have allowed flour to be easily collected. Grinders also bear traces of particular motions. Marked stone-against-stone contact on the edge of the grinders suggests a pivotal movement at the end of the course. The smoothing of this edge, which would have slowed down the grinding motion, was remedied by regular retouching along its entire length. Shiny, greasy smoothing on the backs of grinders can sometimes indicate the positions of the fingertips and the palm of the hands on the object.

20.3.3 Plant processing: evidence and diversity

Archaeobotanical studies all reveal a rather uniform pattern of cultivated plants (Bakels 1999, 2009; Bogaard et al 2011; Diestch-Sellami 2004; Jadin and Heim 2003; Salavert 2011). Hulled wheats, such as einkorn (*Triticum monococcum* L.) and emmer (*Triticum turgidum* subsp. *dicoccon*), were the dominant cereals cultivated while naked cereals, including wheat (*T. turgidum/durum/ aestivum*) and barley (*Hordeum vulgare* subsp. *nudum*), are also observed. Legumes, in particular peas (*Pisum sativum*) and lentils (*Lens culinaris*), are also well represented in the archaeobotanical assemblages. Certain other plants, such as flax (*Linum usitatissimum*) and hazelnuts (*Corylus avellana),* are regularly found in the botanical records (Dietsch-Sellami et al 2008).

Behind the apparent uniformity of the plants consumed, variations in the proportions of these different species have been highlighted within settlements and even within the different houses of a single settlement. Notably, it has been revealed that naked wheat had progressively replaced hulled cereals by the mid-6th mill BC in the Blicquy-Villeneuve-Saint-Germain culture.

The sheer numbers of quern fragments found, as well the results of use-wear analysis, confirm the importance of cereal grinding for the LBK people (Hamon 2008a; Verbaas et van Gijn 2007). Experimental tests have allowed researchers to suggest different treatments carried out prior to grinding, or the use of grinding tools at different stages of cereal transformation. Use-wear visible on some of the grinding tools indicates that high levels of moisture were present during the processing of cereals, suggesting that the grains may have been soaked prior to grinding, possibly in order to facilitate de-husking. Other use-wear traces suggest a higher presence of abrasive matter, such as glumes, which would indicate the processing of hulled wheat. This suggests the existence of different practices or habits in the way that cereals were prepared (Hamon et al 2021).

This is also confirmed by phytolith analysis carried out on a sample of grinding tools. The first tests (Hamon et al 2011) have led to two conclusions. Firstly, grinding tools were used to transform grains that had already been de-husked but incompletely cleaned, as suggested by the finding of residues of leaves, glumes and stems. Secondly, the same grinding tools were used to process not only cereals but also other plants (dicots). These observations are supported by starch grain analysis which confirms the importance of wheat and barley, but which also highlights the processing of legumes and roots/tubers (Hamon et al 2021; Chevalier and Bosquet 2017).

These results confirm the importance of cereal processing in LBK houses, but they also highlight the processing a more diverse range of plant foods. This may indicate the preparation of mixed recipes that included cultivated cereals, legumes and tubers, as well as wild fruits and plants.

20.4 Grinding tool typology, a cultural trend between heritage and innovation

Some recent studies demonstrate that the evolution of grinding tools is not solely linked to the nature of the plants processed (Hamon et al 2019). Grinding tool types and systems were also vested with important cultural value, despite regional variations and local adaptations of the grinding systems to the available natural resources –for blanks and for processing– and to specific types of settlements.

20.4.1 The middle Rhine reference typology

The study of the grinding tools from Langweiler 8 (Rhineland-Palatinate, Germany) demonstrated that at least three main types of associated querns/grinders were used (Fig. 20.5): the first consists of short convex grinders, the second features flat active surfaces and the third consists of overlapping concave grinders (Zimmermann 1988). This typology appears to be relevant for the Rhine Basin (Graefe 2008; Ramminger 2007; Weiner and Schahlich 2006), and seems to be inherited from Central Europe (Pavlu 2000). Variations in the dimensions also depend on the blanks used locally (Table 20.1).

-As for the first type, it associates short flat to convex "loaf-" or "bread-shaped" grinders with flat to concave querns. On the Aldenhovener Plateau, querns display a "rectangular to oval outline, around 40 cm long, around 30 cm wide and up to ca 15 cm thick or even thicker" while the grinder is "of so-called loaf-shape, around 35 cm long, ca 15 cm wide and around 9 cm thick". Their average weight is calculated as ca 3.9 kg (Zimmermann 1988, 735, Fig. 645), ranging between 1,805 kg and 4,940 kg (Weiner and Schahlich 2006). In Hesse, the weight of complete querns varies between 3 kg and 9,1 kg, the weight of grinders between 0,387 and 3,420 kg. In north-east Weterrau, grinding stones at the beginning of their use-life weigh on average 18,3 kg and measure 38 cm in length, 20 cm in width and 18 cm in height (Ramminger 2007). The considerable variations in the average size and weight of grinders between regions may relate to the raw material sources exploited, but may also be linked to functional requirements.

-The second type is quite widespread, with no particular morphological or dimensional characteristics, except the use of adapted flat surfaces for the grinder and the querns.

-The third type, with overlapping grinders, is well known on the Aldenhovener plateau as well as in north-eastern Wetterau, north Hessen, Hesbaye and Hainaut. The particular shape of some of these grinders is striking. Some very similar examples are found in Hesbaye and in the Aldenhovener region: they display a marked "v" section at 90°, and a high degree of concavity which suggests that they may have been shaped from a flake removed from the corner of a block. The largest grinders, all of overlapping type, are very difficult to manipulate, even in a two-handed movement.

In fact, since their arrival in the Rhine valley, LBK grinding tool producers appear to have tried, in so far as was possible, to follow a standard developed in Central Europe. This standard, partly adapted to the exploitation of regular slabs extracted from sandstone outcrops, included specific morphologies and dimensions and, more generally, a shared grinding motion. The homogeneity of grinding tool design, at a large regional scale, appears to be a direct expression of LBK cultural cohesion, as other material productions.

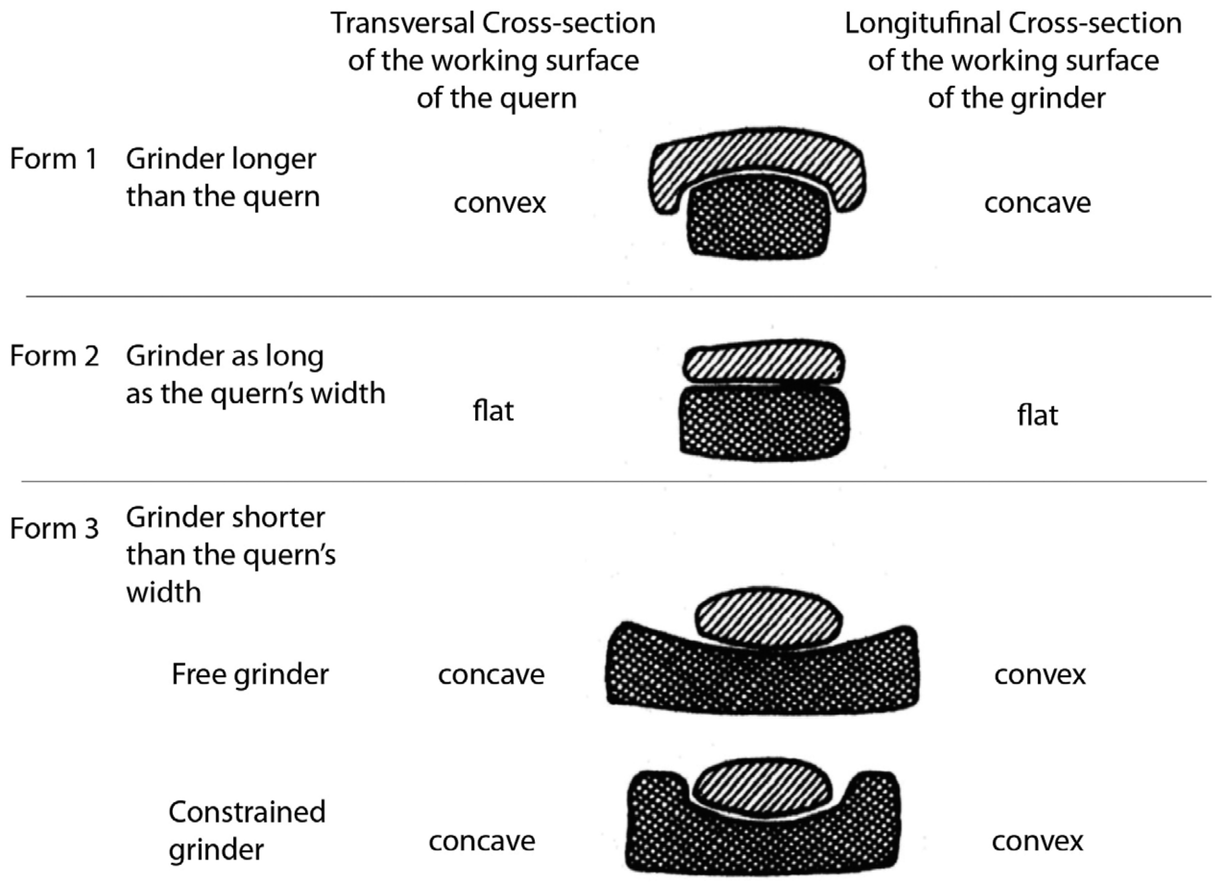

Fig. 20.5 Main LBK types of paired sets of querns and grinders in the middle Rhine Valley and surrounding regions, translated after Zimmermann 1988 and Graefe 2004.

20.4.2 Moving westwards: variations and evolutions

It has been observed that different types of grinding tools co-existed in different contexts throughout the LBK (Table 20.1). The typology developed following the study of the Aldenhovener grinding stones is fully relevant for all parts of the western LBK (Fig. 20.6). In fact, this typology does not appear to be fully adapted to the situation in the lower Rhine region (Verbaas 2014), Hesbaye (Jadin 2003; Hamon and Goaemaere 2007) and Hainaut (Constantin et al 1978; Hamon 2008b).

In Geleen, in the Maastricht region, "the quern fragments can be subdivided in two types: large and flat (N=37) and bread shaped (N=24)" (Verbaas and van Gijn 2007). In addition, they are smaller in size than those found in the middle Rhine region: 25-30 centimetres in length and around 12 centimetres in width. In Elsloo, quadrangular to trapezoidal querns, with flat to concave working surfaces, were made from thin slabs: they generally feature distal edges (Moddermann 1970).

In Hesbaye (Belgium), two quern shapes are recognized (Jadin 2003; Hamon and Goemaere 2007). On the one hand, we observe flat, quadrangular querns made from slabs (27-43 cm long) with none, one or two distal edges, on the other we encounter ovoid to trapezoidal querns (35-50 cm long) with semi-circular plano-convex sections. For equivalent quern lengths of between 25 and 32 cm, short grinders (l= 12-18 cm, t= 3-13 cm) appear to be less thick than overlapping ones (l= 13-15 cm, e= 6-13 cm). Morphological classification must, therefore, also consider a size criterion: at least two sizes of grinder/quern associations coexisted on the sites (with a length by width of approximately 40x22cm and 30x15cm for querns), variations that may relate to specific functions or social meanings.

In the Paris Basin, types and sizes of querns and grinders seem to evolve rapidly between the end of the LBK and the BVSG. While overlapping grinders still occur episodically in Hainaut and in the late LBK of Champagne (Fig. 20.7), they disappear completely from the tool set further to the west (Hamon 2008b; Hamon

	Paris Basin	Hainaut-Hesbaye-Luxembourg	Lower Rhine	Weser-North Hesse
Raw material	Quartzitic tertiary sandstones; sublocal; extracted and collected	Quartzitic tertiary sandstones; extracted slabs; sublocal	Quartzitic tertiary sandstones; extracted slabs and collected	Triassic sandstones, breccias and greywackes; extracted; up to 50 kms
Shaping	Important shaping by flake removals and pecking of the back and sides	Important shaping by flake removals and pecking of the back and sides	Important shaping by flake removals and pecking of the back and sides	Important shaping by flake removals and pecking of the back and sides
Morphology of querns	flat to basin querns with distal and lateral edges	2 types: 1) flat to concave querns with one or two distal edges; 2) oval with plano-convex active surface	flat to concave querns with one or two lateral or distal edges	2 types: 1) flat to concave querns with one or two distal edges; 2) oval with plano-convex active surface
Dimensions querns	L=30-40 cm, l=15-22cm	L=27-45 cm and L=35-55, l=20-27cm, e7-16cm	Estimated L=25-30cm, l=12cm	L=40-45cm, l=25-30cm, e=10-15cm
Grinding system	Short grinders	Short convex grinders, short flat grinders and overlapping concave grinders	Short convex grinders, short flat grinders and overlapping concave grinders	Short convex grinders, short flat grinders and overlapping concave grinders
Dimensions grinders	L=10-30 cm, l=8-12 cm	L=25-32 cm, l=10-20cm, e=6-13cm	no information	L=30-35cm, l=15cm, e=6-9cm
Use-wear and residues analysis	Wheat and barley grinding and dehusking; legumes, tubers, rhizomes, ferns processing	Wheat and barley grinding, widespread ochre processing; possibly oats, acorns and peas processing	Dominant cereals grinding	No use-wear analysis.

Table 20.1 Synthesis of the main characteristics of grinding tools for the 4 regions considered.

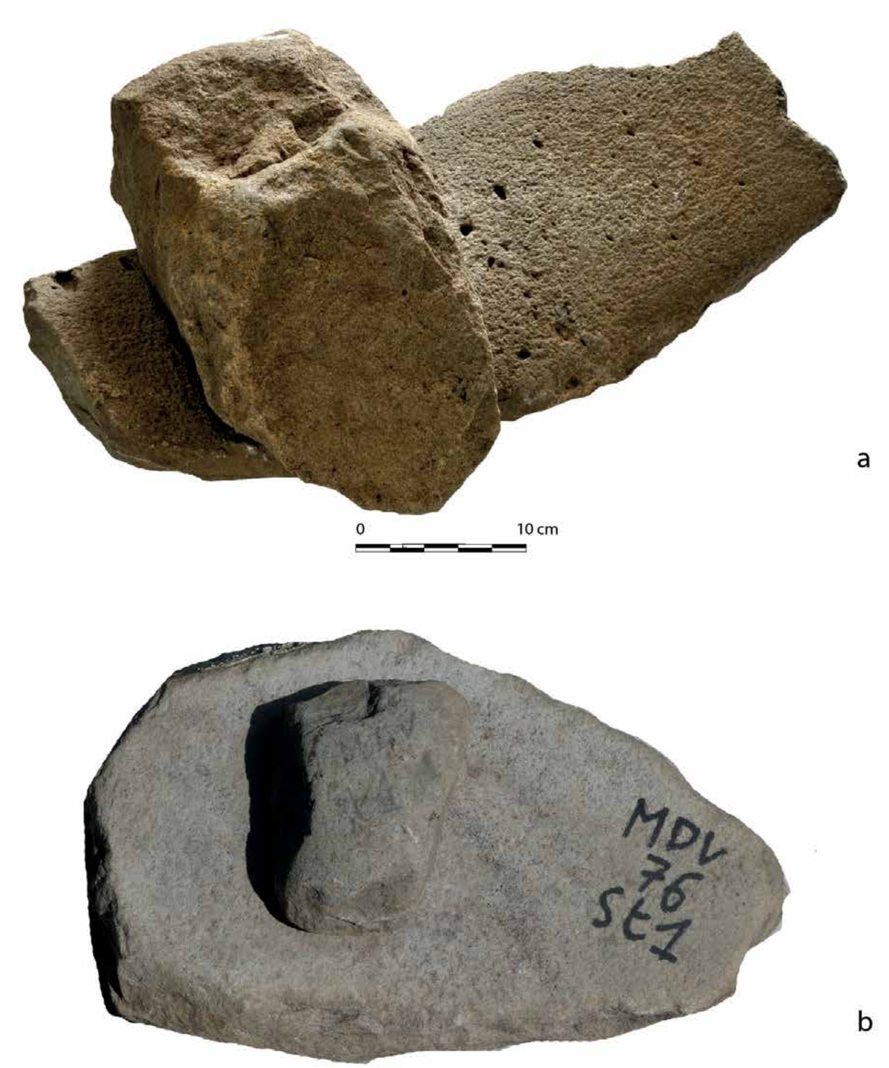

Fig. 20.6 Main LBK types of paired sets of querns and grinders from west of the Rhine. a grinding system with overhanging grinder from Darion – “Colia” (Hesbaye) (photo: P. Cattelain, Collection IRSNB, after Hauzeur et al 2011 fig. 96); b grinding system with short grinder from Menneville Derrière le Village (Aisne valley).

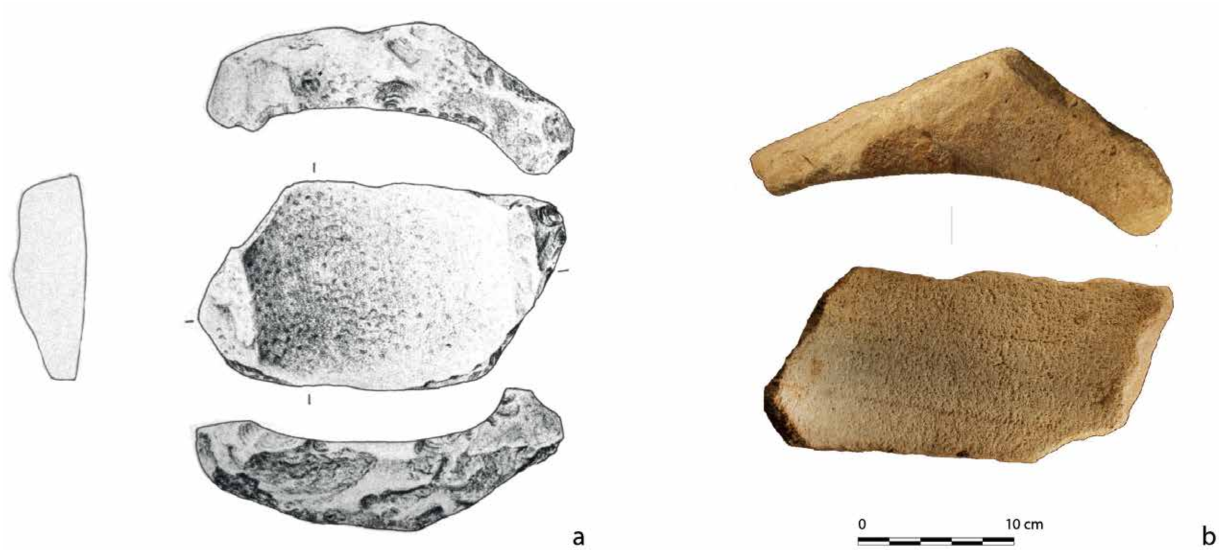

Fig. 20.7 Typical overlapping grinders from the Rhine Valley and Hesbaye. a Langweiler 8 (after Zimmermann 1988); b Remicourt En Bia Flo (after Hamon and Goemaere 2007).

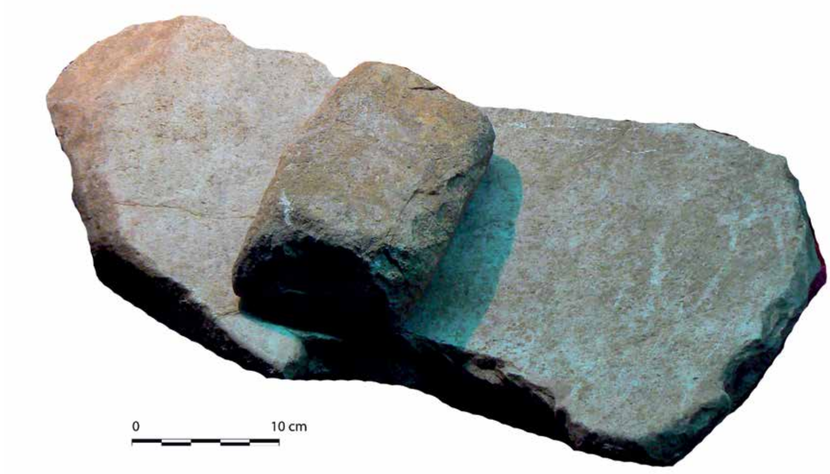

Fig. 20.8 BVSG bread-shaped short grinder with lower quern with distal and proximal edges, BVSG site of Loison-sous-Lens (northern France, after Praud et al 2018; photo: C. Hamon).

et al 2017). Furthermore, LBK "bread-shaped" grinders become shorter in length in the Paris Basin, a tendency that continues in the BVSG (Fig. 20.8). Linked to a broader selection of blanks from riverbeds, the morphology of the querns appears to be more varied, ranging from flat, thin slabs to more massive basin querns (Praud et al 2018; Samzun and Hamon 2004).

In fact, by the end of the sequence, grinding tool typology becomes more diversified, and slowly moves away from the initial LBK standard. By the end of the sequence, all fields of technical production had evolved, including grinding tools, suggesting external influences or internal innovations.

20.4.3 From technological to cultural border by the end of the LBK expansion?

These considerations reinforce the idea of the existence of a "frontier" at the western margins of the LBK territory at the end of the 6th mill BC, at least for grinding systems (Hamon 2008b). Overlapping grinders are identified in the middle LBK of Belgium, the Rhine valley and Champagne, but seem to be completely absent from Late LBK and post-LBK assemblages from 5100 BC onwards in the same region and further west. While the reasons for this major shift in 500 years of grinding technology have not yet been identified, two hypotheses have been suggested. If the coexistence throughout Europe before 5100 BC of these two types of grinding tools was linked to a functional complementarity, then a change in food habits at the end of the 6th mill BC might explain this shift. Moreover, we know that naked cereals (wheat and barley) are common in the macrobotanical remains throughout the LBK, but start to increase significantly on the western margins of the late LBK expansion area (5000-4900 BC), and even more so during the following BVSG culture (4900-4750 BC) (Bakels 1999; Diestch-Sellami 2004; Salavert 2011). However, it is difficult to demonstrate conclusively that overlapping grinders were preferentially used for the de-husking of cereals; if this was the case, then the disappearance of overlapping grinders could be linked to a decrease in the need for de-husking prior to the grains being ground into flour. Alternatively, their disappearance may be a direct consequence of cultural changes, if we consider quern morphology to be a function of cultural traditions. However, the coincidence of these two phenomena – disappearance of a traditional type of grinding tool and increase of naked cereals – on the western margins of the late LBK expansion area may reveal an important shift in the dietary habits of the LBK culture throughout Europe during the second half of the 6th mill BC.

20.5 Conclusion

This overview of LBK grinding systems in the Rhine and Seine basins between 5300 and 4700 BC reveals a strong community of practices. The choice of a particular raw material (quartzitic sandstone), the complex and time-consuming shaping sequences involved in their production as well as their relatively standardized typology define common standards. These characteristics can be considered as expressions of LBK identity, to the same degree as house plans, ceramic decorations or flint blades production. In the next future, it should be possible to map regional variations within these standards, relate them possibly to specific food preparations and practices, and to trace their main chronological evolutions at a large scale.

Acknowledgements

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Chapter 21

Cooking in progress: evolution and diversity of cooking pottery in prehistoric northern Greece and Bulgaria

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Abstract

This paper presents and discusses evolution and diversity patterns of cooking pottery in the regions of northern Greece and Bulgaria throughout the prehistoric periods (late 7th to late 2nd mill BC), where considerable excavated evidence comprises features and artefacts related to subsistence activities, particularly food preparation. The aim is to facilitate the identification of cooking pots in the archaeological record, to enrich datasets on cooking pottery technology and use, and contribute to the reconstruction of prehistoric cooking practices. A multileveled methodology is applied, including systematic bibliographical research and organization of the available data in an especially designed database, firsthand study of original archaeological material selected from representative habitational contexts, along with technological and functional analyses of designated cooking pot samples. The results of our study and analyses demonstrate that prehistoric cooking vessels shared specific, but not exclusive, functional attributes, while their use remained largely versatile. Most importantly, our research suggests that evolution of prehistoric cooking pottery in the area was not linear but rather tangly, involving material transformations and adaptations, ceramic traditions and innovations, as well as rejections and revivals, all related to the given social groups' dynamics.

Keywords: *cooking, pottery, technology, use, Neolithic, Bronze Age*

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21.1 Introduction

Human societies in northern Greece and Bulgaria undergo significant changes over the five millennia that cover the Neolithic, Chalcolithic and Bronze Age periods (late 7th to late 2nd mill BC). However, the history of the area by no means reflects a linear evolution from simpler to more refined or complex patterns of living; the latter can be summarised as a continuum of simple, even rudimentary, modes of settling alternating with substantial, even sometimes monumental, architecture. As such, in all prehistoric periods, Neolithic to Bronze Age, we encounter settlements with groups of dwellings built with light materials and/or partly dug in the ground changing location after a few generations, as well as villages with more stable structures maintained on the same location for centuries or millennia (Andreou et al 1996; Treuil et al 2008; Bailey 2000; Bailey and Panayotov 1995).

Regardless the settlement type and/or intra-site spatial organisation, a large body of the excavated evidence is habitational, comprising various architectural features and artefacts related to subsistence activities, of which food preparation should have been performed on a regular basis. But although research has established *what* people cooked, through the study of botanical and faunal remains and through residue analysis, little is known as to *how* food was being cooked, and in relation to *which* devices, vessels in particular (Valamoti 2009). Research on cooking pottery has advanced considerably in recent years (see e.g. Spataro and Villing 2015; Hruby and Trusty 2017; Ivanova et al 2018), but the positive identification of a cooking pot is still far from being a straightforward process. Publications of pottery assemblages that can be used as reference very rarely touch upon the functional aspect, thus cooking pots are usually grouped together with other "daily use" vessels under the label "coarse ware". This is often inevitable, because when the material is highly fragmented, as commonly encountered in pit features, it is difficult to relate use traces, such as sooting clouds, with specific shapes. On the other hand, complete vessels are usually preserved *in situ* after destruction by fire, the effects of which cover original use traces. Moreover, although cooking pots share some specific typological and technological characteristics directly associated with their function, e.g. curved shapes or coarse fabrics, these are often common with other use categories, such as storage or tableware. Finally, as ethnographic studies have demonstrated, pots did not always have a single use during their lifecycle (Skibo 2013).

In the scope of facilitating the identification of cooking pots in the archaeological record and of improving our knowledge on prehistoric cooking practices, we decided to gather, organize and review the available data in the literature for the above temporal and spatial frame. Furthermore, in order to enrich the limited record on cooking pot technology and use, we conducted first-hand analyses of material selected from representative habitational contexts in northern Greece and Bulgaria. This overview, incorporating the results of current analyses, allows for a synthesis of the diachronic evolution and synchronic distribution of cooking vessels, in relation to settlement patterns and contextual affinities. Moreover, it permits inter- and intra- regional and temporal comparisons on multiple levels, essential to detect traditions and cultural interactions, as well as divergences and innovations in cooking practices. Above all, it enables interpretations on the relations between technological requirements and perceptions, between efficiency and choice, and eventually between cooking and societies.

21.2 Methodology

The methodology applied in the current study followed four stages. The first comprised systematic bibliographical research on the available literature concerning cooking pots from the areas under study, i.e. the regions of Macedonia and Thrace in northern Greece, along with regions in Bulgaria.[1] Bibliographical data were organized in an especially designed database,[2] including detailed fields on cooking pottery context and date, morphological and technological characteristics, use-wear traces and contents. The tables presented in this paper are a product of this endeavor, including all the relevant bibliography, which is not repeated in the text (Tables 21.2-21.6, Fig. 21.1). Information is organized by period and according to site provenance, accompanied by date, type of settlement, and brief mention to contexts. The characteristics of cooking pots are summarized with reference to their fabric (frequency and type of inclusions, porosity, clay matrix, firing), shape (overall, type of rim, base, handles/lugs), ware (surface treatments) and decoration, followed by average dimensions and capacities. The above information was not all available in publications, or not in the same degree of detail, thus in some cases data is fragmentary or rough (e.g. exterior and interior surface treatment of vessels is rarely distinguished in the literature).

The second stage focused on the macroscopic study of selected archaeological cooking pot assemblages. These case studies, representative of the chronological periods and geographical regions under study, include sites dated from the Middle Neolithic throughout to the Late Bronze Age and located across northern Greece and Bulgaria (for

1 This was conducted within a wider framework of literature review of cooking pottery from prehistoric Greece and adjacent areas in the context of the PlantCult project.

2 The database, as part of the PlantCult project, was developed by Themis Roustanis and Panagiotis Tokmakidis, Department of Topography, School of Engineering, Aristotle University of Thessaloniki.

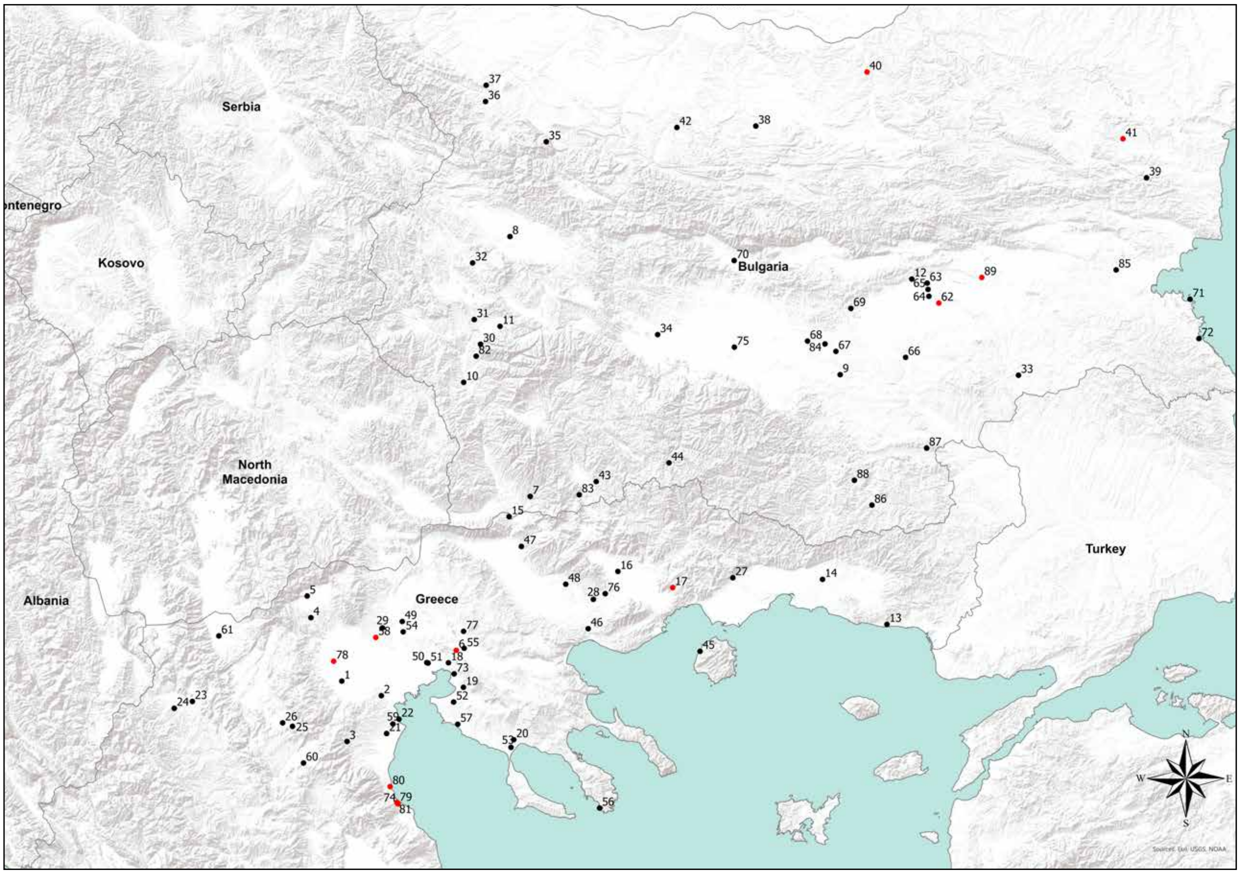

Fig. 21.1 Map indicating the sites mentioned in the text and tables. Highlighted are the sites from which cooking pottery was analyzed in the PlantCult project (© PlantCult Project, Th. Roustanis).

Map No	Site	Region	Date	Studied context	Number of samples
6	Lete I	Northern Greece, Thessaloniki	First half of 6th mill BC	Pit house with thermal structure	13
17	Dikili Tash	Northern Greece, Kavala	4350-4250 BC	Above ground building with thermal structures	16
40	Petko Karavelovo	Northern Bulgaria, Veliko Ternovo	First half of 5th mill BC	Above ground buildings with thermal structures	10
41	Avren	Northern Bulgaria, Varna	4600-4400 BC	Above ground building with thermal structures	2
58	Archondiko	Northern Greece, Giannitsa	2135-1980 BC	Above ground buildings with thermal structures	20
62	Sokol	Southern Bulgaria, Nova Zagora	3200-2600 BC	Above ground buildings with thermal structures	6
74	Valtos-Leptokarya	Northern Greece, Pieria	1885-1695 BC	Above ground building with thermal structures	4
78	Angelochori	Northern Greece, Veroia	1495-1290 BC	Above ground buildings with thermal structures and exterior areas	20
79	Rema Xydias	Northern Greece, Pieria	1489-1296 BC	Apsidal building with thermal structures and exterior areas	10
80	Pigi Artemidos	Northern Greece, Pieria	1390-1100 BC	Open-air spaces, stone structure and pottery kiln	2
81	Trimpina	Northern Greece, Pieria	1600-1400 BC	Pit structures	4
89	Chokoba 18A	Southern Bulgaria, Nova Zagora	1700-1300 BC	Pit structures	5

Table 21.1 The ceramic cooking pot assemblages used as case studies and analyzed in the frame of the PlantCult project.

details see Table 21.1 and Fig. 21.1). The principal criterion for their selection was their correlation with contexts preserving sound evidence on cooking activities, i.e. food processing equipment, such as thermal structures, and food remains. Thus, our study did not include the bulk of the cooking pottery material of the sites under study, but focused on assemblages from specific cooking contexts. Moreover, our emphasis was on vessels preserving sufficient information on their shape, either complete or fragments forming a large part of the vessel profile. Their macroscopic examination involved detailed observations on fabric (frequency and type of inclusions, clay colour), shape (overall with dimensions, type of rim, base, handles/lugs), ware (surface treatment and type of decoration) and use-wear traces (chemical, carbonization and attrition, as well as mechanical alterations, following Skibo 2013) together with capacity estimation.[3]

The third stage involved the petrographic analysis of selected cooking pot samples, representative of their context and type (Table 21.1).[4] Furthermore, some selected non-cooking pot samples were analysed to make comparisons between different functional categories. The scope of the analysis was to acquire refined data on technological issues, such as raw material provenance and processing, building techniques, surface treatment and firing, as well as use alterations reflected on ceramic fabrics.

Finally, all samples were subjected to chemical organic residue analysis to reconstruct their contents, the results of which are not included here as they require the length of a separate paper.[5]

The results of the above research stages are presented below. The review of the bibliographical data on the cooking pot characteristics of each period (presented in detail in the respective tables) is enriched or confronted with the results of the macroscopic and petrographic analyses of archaeological material from our case studies. The approach is qualitative, focusing primarily on the characteristics of pottery wares and fabrics; the inhomogeneous presentation of published material (either sherd accounts or vessel descriptions or, mainly, brief mention of pottery wares) could not allow for quantitative results.

Moreover, it should be noted beforehand, since the presentation is in chronological order, that there are discrepancies in the terms used for the description of periods in the different parts of the territory (between Greece and Bulgaria, but also among different authors). Therefore, all the relative chronological labels are accompanied by indications on absolute chronology, derived directly from 14C dates of specific sites/contexts, or indirectly by comparison with the dated ones. This is indeed the only way to compare contemporaneous assemblages that are described with different names –or, conversely, distinguish between assemblages that are described with the same names but having different contents (see Tsirtsoni 2016).

21.3 Early Neolithic/Middle Neolithic (EN/MN, mid-7th mill BC-first half of 6th mill BC)

A number of radiocarbon dates place the beginning of the Neolithic in Northern Greece in the middle of the 7th mill or slightly earlier, whereas in Bulgaria, the earliest evidence comes from the years around 6100/6000 BC. Accordingly, in Greece, only the first century of the 6th mill is unanimously described as still Early Neolithic, the years between ca 5900/5800-5500/5400 BC being usually termed Middle Neolithic; by contrast, in Bulgaria, the entire interval is described as Early Neolithic.

Data on cooking pots (Table 21.2) derive mostly from flat extended sites, as the majority of long-lived tell sites in the eastern part of the territory conceal their earlier phases below later constructions, or start later, or their cooking vessels are just poorly known from publications, a recurrent problem also in subsequent periods. Architectural features comprise pits of large dimensions, sometimes preserving thermal structures, pointing to their use for habitation, but also above ground buildings, single-roomed, constructed with wood and clay, and containing thermal structures.

The earliest ceramic assemblages comprise open or slightly closed hemispherical bowls, hole mouthed jars, and rather rare necked jars. The majority of vessels is of medium size, the most common rim diameter ranges being 10-25 cm. Carefully made vessels have smoothed and burnished surfaces, while slipping is varying in frequency among the settlements. As can be concluded by the absence or scarcity of use-wear traces related to cooking, i.e. external sooting clouds and internal carbonization, these pots were rarely used for cooking. At Nea Nikomedeia (Table 21.2), despite the presence of many rather low-fired vessels (<750-800^{o}C) manufactured from a variety of pastes containing abundant non-plastic inclusions, the amount of pottery that probably can be connected with cooking is very limited. In contemporaneous sites the existence of cooking pots is not reported.

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3 Vessel capacity was calculated with the software Pot Utility, which was created by Jean Paul Thalmann in ARCANE Project (http://www.arcane.uni-tuebingen.de).

4 Thin sections were prepared in the Geology Department, Aristotle University of Thessaloniki, by N. Kipouros, supervised by Prof. L Papadopoulou. Petrographic examination was conducted by Anastasia Dimoula, in the PlantCult laboratory in CIRI-AUTh, using a Leica DM2700 P polarizing microscope. Images were taken with a Leica MC190 HD microscope camera and using the LAS V4.12 software. Description and characterization of the fabric groups followed the system proposed by Whitbread 1995 with minor modifications.

5 Organic residue analysis was conducted by Prof. O. Craig and Dr. E. Standall, University of York.

Map No	Site	Date (BC)	Type of settlement	Contexts	Fabrics	Shapes	Wares/ Decoration	Dimensions (cm)/ Capacities (l)	References
1	Nea Nikomedeia	6400-6000	Tell	Houses above ground	Coarse-medium, six fabrics, sedimentary, metamorphic or igneous inclusions, porous, low firing temperatures	1. Bowls hemispherical, simple rim, flat base 2. Hole-mouthed, globular	Burnished, smoothed		Yiouni 1996
2	Paliambela	5900-5400	Flat on natural hill	House above ground	Coarse, igneous fragments, porous, low firing temperatures	1. Bowls, hemispherical or conical, simple or outward rim, flat base 2. Hole-mouthed, globular 3. Shallow dish	Smoothed, impressed or incised Dish burnished	1. 3-4 l 3. rd 31	Siamidou 2017; Saridaki 2019
3	Ritini	5900-5500	Flat	Large pit	Coarse-medium, two fabrics, gneiss or metamorphic inclusions, porous, low firing temperatures	1. Bowls, hemispherical or conical, simple or outward rim, flat or disc or ring-shaped 2. Hole-mouthed, globular body, pear-shaped, s-profile, conical neck 3. Shallow dish	Burnished, smoothed, incised or impressed, barbotine Dish burnished	3. rd 58	Intze 2011; Saridaki 2019
4	Apsalos-Grammi	6000-5500	Flat	Pit houses	Medium-coarse, two fabrics, volcanic and/or metamorphic inclusions, organic material, low porous, low firing temperatures	1. Bowls, hemispherical, conical, simple or outward rim 2. Hole-mouthed, simple or s-profile	Burnished, smoothed, barbotine		Vouzara 2009; Saridaki 2011
5	Sosandra	6066-5840	Flat	House interior, thermal structure	Medium-coarse, sand inclusions	1. Bowls, conical or hemispherical, flat base, simple or outward rim, small handles or lugs on body 2. Closed, globular body, s-profile or conical neck, flat base, small handles or lugs on body	Smoothed, burnished, red-slipped band on rim	1. h 23-29, rd 25-40, bd 12-19, wth 0,5-1 2. h 14-24, rd 15-18, bd 8-15, wth 0.5-1	Georgiadou 2015
6	Lete I	first half of 6th mill	Flat	Pit houses, thermal structures	Medium coarse, two fabrics, gneiss or phyllite/shale, organic material, low porous, sieved or tempered, oxidizing conditions, low firing temperatures	1. Open, globular or conical, simple rim, curved or flat base 2. Hole-mouthed, pear-shaped, simple rim, curved base, tubular handles on body	Exterior coarsely burnished, interior smoothed, no slips	1. h 20, rd 24, wth 0.7 / 5 2. h 19, rd 12, wth 0.6 / 2	Dimoula et al 2014; present study
7	Kovachevo, phase I	6000-5600	Flat, on a river terrace	Ovens and built hearths inside houses	Mineral inclusions, vegetal very rare	1. Open, conical, with vertical or outward rim and lugs 2. Hole-mouthed, globular or s-shaped, small lugs on or under the belly	Exterior smoothed or slipped and burnished, frequently barbotine decoration	wth ≥ 0.7 rd 12.5-25 h 10,5-28 Usually around 1,5 l, but some up to 12 l	Vieugué 2010
8	Slatina	6000-5500	Flat	Ovens and built hearths inside houses	Medium, mineral inclusions (sand)	1. Globular with restricted or upright concave rim (s-shaped), lugs on max. diam. 2. Dishes, convex bottom, thickened everted rim, with or without triangular lugs on the rim	1. Exterior smoothed or slipped and burnished, frequently barbotine or relief decoration 2. Exterior rough, unprocessed, interior smoothed	1. rd 12-30 2. Not specified	Nikolov 1992; Nikolov 1987
9	Yabalkovo	6000-5500	Flat	No house plan, isolated hearths and pits	1. Medium 2. Coarse (with lots of organics)	1. Globular, flat base, simple (restricted) or upright concave rim (s-shaped); impressed coil at mid-height of the walls 2. Oval -dish	1. Smoothed; relief and impressed decoration 2. No precision	1. rd 11-15, h 10-18 2. opening d (int.) min. 19, max. 25, depth (int.) 5; wth 1-6	Roodenberg et al 2014
10	Balgarchevo phase I	5700-5500	Flat, on a river terrace	Ovens and built hearths inside houses	Medium-coarse	1. Hemispherical or spherical bowls, lugs at mid-height of the walls 2. Dishes, convex bottom, thickened everted rim, with or without triangular lugs on the rim	1. Exterior-interior smoothed; rarely barbotine and interior. smoothed 2. Exterior rough, unprocessed, interior smoothed	1. rd 16-35 2. rd 35-42	Pernicheva-Perets et al 2011
11	Kremenik (Sapareva Banja)	5700-5400	Flat, on a river terrace	Houses; ovens interior	Medium-coarse	Dishes, convex bottom, thickened everted rim, with or without triangular lugs on the rim	Exterior rough, interior smoothed	rd 30-46, h 5-20	Georgiev et al 1986; Nikolov 1987
12	Karanovo, phases I-II/III	5600-5500	Tell	No house plans		Globular with restricted or upright concave rim (s-shaped),	Smoothed or barbotine		Nikolov 2002

Table 21.2. Summary of EN-MN cooking pottery characteristics.

Fig. 21.2 MN cooking pottery wares. a bowl from Lete I; b hole mouthed vessel from Lete I; c cooking dish from Ritini (© a, b PlantCult Project, A. Dimoula; c after Intze 2011, plate 9).

It is with the beginning of the 6th mill BC that there is uncontested evidence on the use of pottery for cooking, supported by content analysis (Whelton et al 2018). Cooking vessels of this period (Table 21.2) can be divided into three broad typological categories. The first includes open bowls, hemispherical or conical, with simple or outward rim and flat or curved base (average h 15-30, d rim 20-40, wall th 0.5-1 cm) (Fig. 21.2a). The second comprises hole-mouthed vessels, with a globular or pear-shaped body, with conical necks or simple rims and flat or curved bases (average h 10-30, d rim 10-25, wall th 0.5-1 cm) (Fig. 21.2b). Both types occasionally feature lugs, usually perforated, on their body. The third category includes large in diameter (30-60 cm) shallow vessels with everted rims and, sporadically, two large triangular lugs on the rim (Fig. 21.2c). Not all three categories are equally distributed in our study area: hole-mouthed vessels are recorded in practically all the sites, whereas open bowls are well-represented at the Greek sites but seem rare in Bulgaria. The third category is documented in the middle Struma valley, while two specimens have been recorded from sites in Pieria. It is possibly later in date than the other two and spread geographically in the following period (see Dimoula et al 2022).

The cooking pots we studied, from a pit house equipped with a thermal structure at Lete I (Tzanavari and Filis 2002, 2009; Tzanavari 2017; Dimoula et al 2014), belong to the first two categories (Fig. 21.2a and b). Petrographic analysis identified two fabric groups, both medium to coarse grained with a homogeneous groundmass containing well sorted silicates and micas, pointing to processing by sieving. The first group, more abundant, is characterized by the presence of gneiss fragments and their mineral components, while the second by the addition of phyllite/shale fragments (Fig. 21.3a and b). Both compositions refer to the geological setting of the site, though point to different raw material sources. The large inclusions were probably deliberately added to the clay, as indicated by their bimodal distribution and subangular shape, pointing to crushing. However, there are few cases where the large sized inclusions are also well sorted, possibly indicating coarse clay sieving. Finally, both fabrics contain organic material in the form of long plant stems, possibly deliberately added in the clay (Fig. 21.3c). Similar observations are reported from other sites, i.e. limited in number fabrics, coarse, porous and mineral tempered (Table 21.2).

The dominant technique for the construction of cooking pots at all sites is coiling, whereas cooking dishes could have been built with coils or slabs, with the help of a mould (see Dimoula et al 2020, 275). At Lete I, the exterior surfaces of

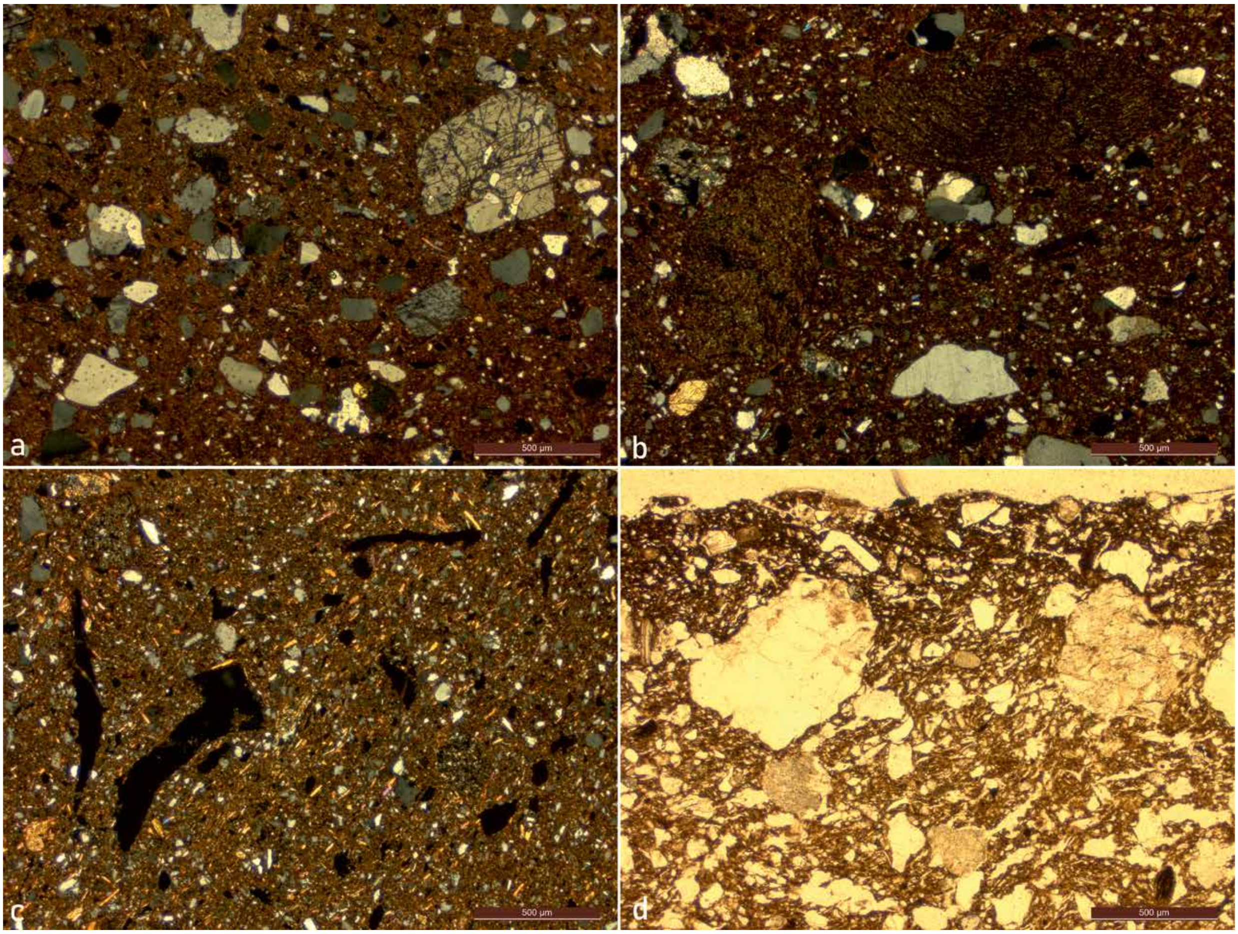

Fig. 21.3 Microphotographs of MN cooking pottery fabrics in thin section from Lete I. a coarse, gneiss inclusions (crossed polars, XP); b coarse, phyllite/shale inclusions (XP); c medium, organic inclusions (XP); d. absorption of charred material in internal vessel wall (plain polarized light, PPL) (© PlantCult Project, A. Dimoula).

cooking pots are unslipped and burnished, their interior simply smoothed, and decoration is absent. But roughly contemporary cooking pots from other sites have the exterior surface burnished, even slipped, or covered with impressed, incised or barbotine decoration (Table 21.2). The latter could have also had a functional role, preserving the outer surface from degradation, thus prolonging the vessels' duration, facilitating heat transfer or even vessel handling (Pierce 2005). Cooking dishes are smoothed or burnished on the interior, the outer surface commonly being left rough. Firing in oxidizing conditions and low temperatures (below 800°C) suggested by the analysis of Lete I fabrics, accounts for most ceramic assemblages.

Concerning use-wear traces, exterior sooting clouds are referred mainly on the base and belly of cooking pots, whereas interior carbonization is found commonly on the bottom. Evidence from Lete I cooking pots allows to refine the picture: flat bases are oxidized with sooting clouds starting higher, while curved ones are covered with sooting clouds, indicating placement among fuel in the first case and above fire for the second. It is worth mentioning that the majority of bowl curved bases are heavily worn on the exterior, possibly due to their extended use on stones or over the hearth (Fig. 21.4a and b). In contrast, the bases of the hole-mouthed jars with tubular lugs are commonly not worn, pointing to their hanging above fire. The vessels' interior has extensive carbonization, particularly on the bottom surface, but also on the lower walls. In thin section, it is clear that charred food particles have penetrated the vessel walls (Fig. 21.3d). The capacity of the open bowls is estimated to 5 l, while the hole-mouthed jars seem to be smaller, with 2 l capacity; but the fragmentary state of the material does not rule out the possible existence of bigger or smaller vessels, too.

Fig. 21.4 MN cooking pottery use-wear traces on bowl from Lete I. a interior, carbonization on bottom; b exterior, worn base (© PlantCult Project, A. Dimoula).

21.4 Middle/Late Neolithic I (MN/LNI, ca 5500/5400-4900/4800 BC)

The second half of the 6th and early 5th mill BC is described in Northern Greece as Late Neolithic I; in Bulgaria, the same interval is described as Middle (ca 5500-5300) and Late Neolithic (ca 5300-4900). This period is marked by an increase in the number and extent of sites, belonging to two types that coexist in the biggest part of the territory: tells and flat settlements. Tell sites mainly result from the building remains of above-ground built houses, constructed with wood and clay and containing thermal structures. Flat-extended settlements commonly comprise dug-in structures, houses or pits of various uses, with thermal structures often encountered in exterior spaces. On the other hand, examples of flat sites with rectangular houses are also present in inland or lakeside settlements. Cooking pots are found in all contexts, in house interiors and open-air spaces, near or away from thermal structures, as also related to depositional features, such as ditches and pits.

The main types of cooking pots can be broadly grouped in four categories (Table 21.3). The first includes open shapes, spherical, hemispherical or conical bowls with a flat base and simple or outward rim (average d rim 15-30 cm, capacity 2.5-8 l) (Fig. 21.5a). Shallower vessels are also present, such as basins, which can be confused with conical bowls when fragmentary, as also oval in plan shallow vessels (characterized as boat-shaped in Dispilio). The second category comprises hole-mouthed vessels, with globular or biconical body, flat base and simple rim (average d rim 15-30 cm, capacity 6-10 l) (Fig. 21.5b). The third includes legged vessels, open or hole-mouthed, with cylindrical, globular or s-profile shape, flat or curved base, and supported by three or four legs (average h 15-30, d rim 15-30, wall th 0,5-1.5 cm, capacity up to 8 l) (Fig. 21.5c). All the above types commonly feature lugs, tongue, mastoid or knobs, and rarely handles. Finally, widespread is the use of large in diameter and shallow cooking dishes (h <10, d rim 30-70, wall th 0.4-0.8 cm), circular or oval in plan, with curved or flat base, varied rim formation (simple, thickened, outturned), and occasionally having lugs on the rim (triangular or tongue-shaped) (Fig. 21.5d).

The distribution of the above types among the sites is by no means equal. The very generic image we have formed is that the second category of vessels, the hole-mouthed ones, prevail across the entire region. The first category, the open vessels, are also very common, but are met mainly in the central part of Macedonia, a possible result of their easier identification among fragmented assemblages, as the ones commonly met in pit features; a few almost complete vessels are known though from Dikili Tash, in eastern Macedonia (Tsirtsoni 2001, 30-31). Legged pots are frequent in the eastern and western parts, with three and four legs respectively, but are rather indiscernible in the central part, again possibly due to the high fragmentation of the material, i.e. there are many individual legs but not complete profiles. On the other hand, cooking dishes, the fourth category, are highly recognizable even in very fragmented condition due to their characteristic rough exterior ware. In eastern areas circular in plan dishes with curved bases are more common, while in western sites oval in plan dishes with flat bases predominate (Dimoula et al 2022).

The fabrics of the cooking pots are coarse to medium-grained with varied compositions related to the geological environment of each site (Table 21.3). Interestingly, the fabrics of each site do not follow a single recipe, but are commonly diverse in composition, reaching up to five fabric groups in cases. This points to the exploitation of different raw material sources and the application of different techniques in their processing, as described above for the earlier pots. The inclusions are predominantly mineral, but organic material, such as shells or plant remains, are met in the majority of the fabrics. Specifically, at Dikili Tash, which provided one of our case studies for the next period and is therefore

Fig. 21.5 LNI cooking pottery wares from Dikili Tash. a conical bowl; b hole mouthed vessel; c legged vessel; d cooking dish (©Ecole française d'Athènes/Dikili Tash research project. a, b, c P. Collet, d Z. Tsirtsoni).

interesting to consider in a long-term perspective, the cooking pots (conical bowls, hole-mouthed, tripods and dishes) are characterised by three fabric groups, all coarse-medium grained, with the majority containing igneous and metamorphic rock fragments (see Tsirtsoni and Yiouni 2002). Surface treatment of cooking pots in all sites includes smoothing and less commonly burnishing for both the exterior and interior. Only in the case of cooking dishes, the exterior surface is always left rough. Decoration very rarely includes limited plastic, impressed or incised interventions, or barbotine surfaces. Vessels are generally fired in varied conditions (oxidizing-reduced) and low firing temperatures, <850 ^{o}C. Previous use-wear analysis has shown that flat-based vessels, either open or hole-mouthed, were used either in contact with fuel, as evidenced by their oxidized bases, or in distance from fire, indicated by the presence of sooting clouds on their base (Urem-Kotsou 2006). Distance could be achieved by the support of a stand, stone or clay, or by hanging the vessel above fire, or by its placement on top openings of domed hearths (see e.g. Dimoula et al 2020, 277). In both cases sootings clouds are also developed on the vessel body. Similarly, legged pots were used with fuel or fire placed below their base, resulting in either oxidization or sooting clouds depending on the intensity of the fire. As for the interior, it has been observed that carbon deposits are accumulated on the vessel bottom, while low liquid contents are assumed to leave traces on the vessel walls and high liquid contents on the upper part, above liquid level (Urem-Kotsou 2006). Cooking dishes occasionally have sooting clouds on their exterior surface and below their rim, pointing to their placement among fuel. In contrast, their interior is commonly clean from fire traces, apart from very sporadic patches.

Map No	Site	Date (BC)	Type of settlement	Contexts	Fabrics	Shapes	Wares/Decoration	Dimensions (cm)/ Capacities (l)	References
10	Balgarchevo phase II-III	5500-5000	Flat, on a river terrace	Houses with thermal structures	Medium-coarse	1. Spherical bowls 2. Dishes, convex bottom, thickened everted rim, with or without triangular lugs on the rim	1. Exterior smoothed, or rarely coarse or barbotine; interior smoothed 2. Exterior rough, interior smoothed	1. rd 20-30 2. rd 30-40	Pernicheva-Perets et al 2011
12	Karanovo III-IV	5500-4900	Tell	Houses with thermal structures		Globular, hole-mouthed, flat base; no lugs or handles	Smoothed, impressed coil on rim and max. diam and impressed/ incised decoration	rd 11-25, bd 11-20, maxd 18-27, h 13-20	Hiller and Nikolov 2002, 2005
13	Makri, phase II	5500-5300	Tell	Houses, thermal structures	Coarse, metamorphic or igneous inclusions, organic material, firing between 750-850 °C	1. Hole-mouthed, biconical, globular, flat base, simple or outward rim, lugs on carination 2. Four-legged, open or hole-mouthed, curved base, simple rim, vertical handles	Smoothed, burnished, impressed, incised	1. h 20, rd 20 2. h 15, rd 20	Efstratiou et al 1998; Yiouni 1995
14	Paradimi, phases I-III	5500-5300	Tell		Coarse	1. Hole-mouthed, biconical, globular, flat base, simple rim, lugs on carination 2. Jar with vertical handles or lugs on shoulder 3. Four-legged, open or hole-mouthed, curved base, simple rim, vertical handles	Smoothed, burnished, impressed, incised	1.h 9-23, rd 9-23 2. h 15-30, rd 16-37 3. h 8-23, rd 13-29	Bakalakis and Sakellariou 1981
15	Promachon-Topolnica, phases II-III	?5500-4900	Tell	Houses, sub-terranean structures, thermal structures	Coarse, metamorphic, silicates	1. Hole-mouthed, biconical, globular, flat base, simple rim, lugs on carination 2. Tripod, hole-mouthed, globular, horizontal handles and lugs	Smoothed, coarse		Koukouli-Chrysanthaki et al 2007; Yiouni et al 1998
16	Sitagroi, phases I-II	5500-4900	Tell	Houses with thermal structures	Coarse, mineral and organic inclusions	1. Open or hole-mouthed, biconical, globular, flat base, simple rim, with or without lugs on carination 2. Shallow dish, flat or curved base, thickened rim, perforated lugs 3. Legged pots, fragments	1. Smoothed, impressed, incised, also on carination 2. Coarse exterior, smoothed interior	1. rd 24-25 2. rd 20	Keighley 1986; Gardner 2003
17	Dikili Tash LNI (ex-phase I)	5300-4800	Tell	Houses with thermal structures	Coarse, three fabrics, igneous and metamorphic inclusions, silicates, organic material	1. Open conical, flat base, simple rim, lugs or handles under the rim or in the upper part of the wall 2. Hole-mouthed, biconical or globular, flat base, simple rim, lugs or horizontal handles on carination 3. Tripod, cylindrical, curved or almost flat base, simple rim, lugs or horizontal handles under the rim or in the upper part of the wall 4. Shallow dish, curved base, outturned rim, no lugs	1-3. Smoothed, burnished 4. Coarse exterior, smoothed interior	1. h 19-23, rd 20-38, wth 0.6-1.2/ 7,5-13 2. h 12-25, rd 10-26, max d 16-33/ up to 10 3. h 15-20, leg h 4-10, rd 18-28, wth 0.5-1.5 / up to 8 4. h 10, rd 55-60, wth 0.4-0.8	Tsirtsoni 2000, 2001; Tsirtsoni and Yiouni 2002; Darcque et al 2007; Darcque et al 2020
18	Stavroupoli phase I	5500-4900	Flat	Rectangular houses, thermal structures interior and exterior	Coarse-medium, five fabrics, mainly basic and ultrabasic inclusions or schist	1. Open, spherical, hemispherical, conical, flat base, simple or outward rim, lugs 2. Hole-mouthed, globular, biconical, simple rim or low neck 3. Shallow dishes, hemispherical or conical, simple, thick or outturned rim 4. Basins, conical, flat base, simple rim, lugs 5. Legged pots, fragments	1-2. Burnished or smoothed exterior and interior rarely coarse 3. Coarse exterior, well smoothed interior	1. rd 16-30 / 2.5-8 2. rd 18-29 / 6-8	Lymperaki et al 2016; Urem-Kotsou and Dimitriadis 2002, 2004
19	Thermi	5500-4900	Flat	Pits and open cobbled areas, thermal structures	Coarse, mineral inclusions Medium, mineral and organic inclusions	1. Open, spherical, hemispherical, conical, flat base, vertical handles 2. Shallow dishes, flat base, simple, thickened, flat rim	1. Smoothed, coarse 2. Coarse exterior, burnished or smoothed interior	2. rd 20-50	Urem-Kotsou 1998; Elezi 2014
20	Olynthus	?5500-4900	Flat		Coarse	Tripod pot (leg height unknown), flat base, simple rim, four tongue lugs at the rim	Coarsely burnished	h 17.5, rd 20.5, bd 21, wth 0.5	Mylonas 1929
21	Kato Agios Ioannis	5500-4900	Flat	Pits	Coarse, mineral inclusions	1. Hole-mouthed, globular, biconical, flat base, simple rim, lugs 2. Shallow dishes, simple or thickened rim	1. Smoothed exterior and interior 2. Coarse exterior, smoothed interior	1. rd 18, bd 10 2. rd 54-64	Karanika 2014

Map No	Site	Date (BC)	Type of settlement	Contexts	Fabrics	Shapes	Wares/Decoration	Dimensions (cm)/ Capacities (l)	References
22	Makrygialos phase I	5450-4950	Flat	Pits, houses or disposal, thermal structures exterior, ditches	Coarse, shells and silicate inclusions, porous, low fired Coarse, silicate inclusions, porous, low fired	1. Open or hole-mouthed, hemispherical, conical, globular, biconical, flat base, tongue or mastoid lugs or knobs, strap handles, multiple pierced lugs 2. Shallow dishes, flat base, simple, thick or outturned rim, triangular or tongue lugs 3. Basins, conical, flat base, simple rim, lugs simple or tongue 4. Legged pots	1. Burnished exterior and interior, rarely coarse, very rarely impressed or barbotine 2. Coarse exterior, well smoothed interior, very rarely impressions on rim 3. Burnished exterior and interior	1. rd <20, 20-35, 36-43, 43-59 2. rd 30-41, 42-54, 56-59, >70 3. rd 15-25	Urem-Kotsou 2006; Saridaki 2019
23	Dispilio, east sector	5500-4800	Flat	Post-framed houses	Coarse, basic rock fragments	1. Open or hole-mouthed, flat base 2. Four-legged, open, spherical, s-profile, curved base, lugs 3. Shallow dishes, flat base, triangular lugs 4. Boat-shaped, flat base, simple rim, legged specimens	Smoothed, impressed, incised or plastic decoration	2. h 13-29, rd 9-24 4. l. 28.5, w. 13, wth 1-1.3	Sophronidou 2002; Sophronidou and Tsirtsoni 2007
24	Avgi, phases I-II	5500-4900	Flat	Houses, interior and exterior thermal structures	Coarse	Shallow dishes, simple, thickened or outturned rim, flat base, triangular lugs	Coarse exterior, smoothed or burnished interior		Katsikaridis 2021
25	Toumba Kremasti Koilada, phases I-III	5300-4900	Tell	Pits	Coarse	Shallow dishes, thickened rim, flat base	Coarse exterior, smoothed or burnished interior		Hondroyianni 2009
26	Megalo Nisi Galanis LN	5200-5000	Tell	No house plans, no structures	1. Coarse, non-calcareous clays, serpentine, schist, talc 2. Three fabrics: sand, schist, and micas	1. Hole-mouthed, carinated or squashed, one or more lugs attached to the lower part 2. Shallow dishes, fragments	1. Scraped or pitted interior, smoothed, slipped and lightly polished exterior 2. Smoothed or lightly polished interior, unprocessed exterior	1. /5 2. rd 35-45	Kalogirou 1994; Fotiadis et al 2000, 2019

Table 21.3. Summary of MN/LNI cooking pottery characteristics.

21.5 Late Neolithic II/Final Neolithic – Chalcolithic period (LNII/FN, ca 4900/4800-4000/3700 BC)

Different terms are used to describe the rest of the 5th mill BC in the different parts of the study area. In Greece, the years until 4600/4500 are usually termed Late Neolithic II, whereas the following centuries are usually termed Final Neolithic or Chalcolithic. In Bulgaria, the entire period is called Chalcolithic, and subdivided in Early-Middle (until 4600/4500 BC) and Late (after that). In both countries, the biggest part of the evidence concerns the years down to 4250 BC. The period between 4250 and 3800/3700 BC is still included in the Greek "Final Neolithic" but is actually rarely attested. In Bulgaria, where it is also rare, it is described, according to the authors as Late Chalcolithic, Final Chalcolithic or Transitional period.

Information on cooking pottery for these periods derives mostly from the eastern part of the Greek region and from Bulgaria (Table 21.4). Globular or biconical jars, either hole-mouthed or with an upright concave rim (s-shaped) appear to dominate the assemblages, in medium and small sizes, less large (average h 10-20/20-30 cm, rd 10-15/15-30 cm, capacity 1.5-8 l) (Fig. 21.6a, b, Fig. 21.7). The second in frequency category includes bowls, hemispherical or conical (average h 10-15/20-30 cm, rd 10-20/25-30 cm, capacity up to 9l). Both types have flat bases and commonly feature lugs or small handles, horizontal or vertical, and rarely spouts. After the mid 5th mill BC, small sized collared jars, with globular or piriform body, are attested, again flat based and with small lugs or horizontal handles below the rim (average h 10-20 cm, rd 7-11 cm) (Fig. 21.6b). Their use for cooking has not been formally proposed so far, but this seems to us as a plausible hypothesis, given especially contextual evidence from Dikili Tash, where such a vessel was found very close to one of the ovens of House 1 (see below).

However, the most striking change in the cooking assemblages of this period is the disappearance of legged pots and cooking dishes. A new utensil appears in some sites/areas that could compensate the disappearance of legged pots: the conical or cylindrical stand (Fig. 21.6c). Although its flat upper surface could have supported other vessels over fire, this is very unlikely as: a. most of these stands are decorated, b. none of them has been contextually associated with cooking pots, and c. cooking pot bases are usually much larger than the opening on top of these stands. Thus, they could be used for heating small quantities of foods, rather than for proper cooking.

To acquire more refined data for these phases, we studied cooking pots from two sites in north -central and eastern- Bulgaria, respectively Petko Karavelovo and Avren-Bobata, as well as from Dikili Tash in eastern Macedonia. At Petko Karavelovo (Chohadzhiev et al 2017, 2019), several burnt houses were investigated, rectangular in shape,

Map No	Site	Date (BC)	Type of settlement	Contexts	Fabrics	Shapes	Wares/Decoration	Dimensions (cm)/ Capacities (l)	References
12	Karanovo, phase V	4900-4500	Tell	Houses with ovens	Medium-coarse	Globular, flat base, with concave restricted or upright rim; no handles or lugs	Smooth interior/exterior, or smooth upper and rough lower part; applied coils or pellets	rd 13-25, maxd 17-36, h 12-25	Hiller and Nikolov 2005
12	Karanovo, phase VI	4500-4250	Tell	Houses with ovens	Medium-coarse	Globular, flat base, hole-mouthed or with concave restricted rim; four small lugs or impressed coils on the max. diam.	Smooth interior, barbotine/rough exterior, except for a smoothed band under the rim	rd 11-19, maxd 14-25, bd 10-13, h 9-19	Hiller and Nikolov 2005
16	Sitagroi Phase III	4900-4250	Tell	No house plan, one hearth	Coarse, mineral and organic inclusions	1. Globular/biconical, flat base, upright rim, two or four lugs on the belly 2. Conical stand, flat on top	1. Smoothed 2. Smoothed exterior, incised decoration, unprocessed interior	1. h 12--27, rd 16-24 2. rd 20	Evans 1986; Gardner 2003
17	Dikili Tash, phase LNII-early (ex-phase II)	4800-4500	Tell	Interior ovens, dug-in (?) house with interior hearth area	Medium-coarse	1. Globular, flat base, with concave restricted or upright rim; no handles/lugs 2. Globular, flat base, hole-mouthed, four lugs on max. diam. 3. Conical stand, flat on top	1. Smoothed interior/exterior, or well-polished exterior 2. Smoothed interior/exterior 3. Smoothed exterior, incised decoration, unprocessed interior	1-2. h 13-20, rd 12-22, maxd 17-27, wth 0,5-1 3. h 17, bd 31	Demoule 2004; Tsirtsoni 2000; Darcque et al 2011; Tsirtsoni et al 2018; Treuil et al 2020
17	Dikili Tash, phase LNII-mature (ex-phase II)	4500-4250	Tell	Above-ground houses with interior ovens	Medium-coarse	1. Hole-mouthed, globular, flat base, simple rim, mastoid or knobbed lugs and/or horizontal handles on carination 2. Piriform or collared globular pots, with small handles or lugs under the rim 3. Conical stand, flat on top	1. Smoothed interior, smoothed or polished exterior; impressed coil on the belly, or grooved decoration on the upper part 2. Smoothed interior/exterior or barbotine/impressed 3. Smoothed exterior, incised decoration, unprocessed interior	1. h 10-15/21-27, rd 10-15/16-21, bd 16-17, maxd 14-18/24-36, wth 0.5-1.15 / 1.5-8 2. rd 8-11, maxd 14-21, h 14-17 3. h 25, bd 35, d. hole on top 6-10	Darcque et al 2011; Tsirtsoni 2016; Koukouli et al 2020; present study
17	Dikili Tash, phase FN/FCh	4250-3700	Tell	No house plan, no thermal structures	Medium; fabric analysis in progress	1. Globular with restricted opening, upright rim, no handles 2. Ovoid body, upright rim, two vertical handles on the shoulder 3. Open, s-shaped bowl, two vertical handles under the rim	1-2. Smoothed interior/exterior 3. Smoothed interior/exterior, ridged or impressed	1. rd 19-20 2. rd 22, maxd 28, h 22 3. rd 27, h 15	Tsirtsoni and Malamidou 2015-2016
27	Paradeisos	5th mill	Flat, on top of a natural hill	No house plan		Conical stand, flat on top	Smoothed exterior, incised decoration, unprocessed interior	bd 25, wth 1.1-2	Hellström 1987
28	Dimitra, phase III	5th mill	Tell		Medium-coarse	1. Open, hemispherical; two horizontal handles at the rim, or horizontal lugs at mid-height 2. Stands	1. Smoothed or polished exterior 2. Smoothed exterior, incised decoration, unprocessed interior	1. rd 11-17	Grammenos 1991
22	Makrygialos phase II	4900-4600	Flat	Pits and open areas with structures	Medium-coarse, mostly shells and/ or or sand, rarely limestone, oxidized or mixed firing conditions	1. Open or hole-mouthed, flat base, simple rim, mastoid or oblong lugs, ellipsoid or cylindrical handles, on rim or body 2. Dishes, convex base	1. Burnished or smoothed, rarely rough, few impressed or incised 2. Rough exterior, burnished interior	1. h 15-40, rd 12-38 2. rd >40	Vlachos 2009
26	Megalo Nisi Galanis, FN	4700-4500	Tell	No house plan	Coarse, two fabrics, silicates and metamorphic inclusions	1. Open, hemispherical, flat base, lugs 2. Hole-mouthed, globular, conical, piriform, flat base, handles, lugs	Smoothed	1. /Up to 9 2. /3-16	Kalogirou 1994; Fotiadis et al 2019
29	Agrosykia	mid 5th mill	Tell		Medium-coarse	Hole-mouthed or hemispherical; vertical handles under the rim, or lugs at the rim	Smoothed, coarse	rd 9-28	Aslanis 2007
30	Slatino	4900-4500	Flat	Houses with ovens	Coarse	Globular, simple restricted mouth or concave rim, flat base, no lugs or two lugs on the shoulder or the belly	Smooth interior/exterior	rd 9-15, h 10-15	Chohadzhiev 2006; Georgieva 2012
31	Dyakovo	4600-4250	Flat		Coarse	1. Hemispherical bowl, flat base; two lugs at mid-height 2. Conical bowl, flat base, one vertical handle and one lug under the rim 3. Collared-pots, with small handles on the shoulder	1-2. Smooth interior, rough or barbotine exterior with smoothed band under the rim and impressions between the two 3. Band with impressed or barbotine decoration on the shoulder	1-2. rd 12-17, h 12-15 3. Small to medium: rd 7, h 15	Georgieva 2012
32	Peklyuk	4600-4250	Flat?		Coarse	1. Globular, upright rim, without or with two lugs on max diam. 2. Collared-pots, with small handles on the shoulder	1. Smooth interior/exterior 2. Smooth exterior, barbotine lower part	1. rd 10-11, h 11-16 2. rd 7, h 18	Georgieva 2012

Map No	Site	Date (BC)	Type of settlement	Contexts	Fabrics	Shapes	Wares/Decoration	Dimensions (cm)/ Capacities (l)	References
33	Drama-Merdzhumekja	4900-4250	Tell	Houses with ovens.		Globular, flat base, hole-mouthed, or with concave upright rim (s-shaped); no handles or lugs; some specimens with spout	Smooth interior/exterior, or impressed/grooved exterior except a band under the rim; applied coils or pellets	rd 9-15, maxd 12-18, h 9-12	Fol et al 1989
34	Yunatsite	4600-4250	Tell	Houses with ovens	Coarse	1. Hemispherical/ conical bowl, flat base; two or four lugs at mid-height 2. Globular, flat base; two or four small lugs on the shoulder; one specimen with spout 3. Collared-pots, with small handles on the shoulder	1. Smooth interior, rough or barbotine exterior 2. Smooth interior, rough or barbotine exterior with a smoothed band under the rim and impres-sions between the two 3. Band with impressed or barbotine decoration on the shoulder	1-2. rd 14-16, h 10-15 3. rd 7-10, h 13-20	Georgieva 2012
35	Zaminets	4900-4000	Flat		Coarse	1. Hemispherical/ conical, flat base; alternating vertical handles and lugs at mid-height; "platform" running under the interior rim 2. Globular, beaded or upright rim, flat base, two or four lugs 3. Collared-pots, with small handles on the shoulder	1. Smooth interior, barbotine exterior with a smoothed band under the rim and impressions between 2. Smooth interior/exterior 3. Band with impressed or barbotine decoration on the shoulder	1. rd 24-28, h 26-30 2. rd 7-9, h 7-11 3. rd 7-9, h 10-15	Georgieva 2012
36	Krivodol	4600-4000	Tell		Coarse	1. Conical, slightly convex rim, flat base; alternating vertical handles and lugs at mid-height; spout under the rim with flat interior lug above the hole 2. Biconical, flat base, four lugs 3. Globular, upright rim, no or two or four lugs at mid-height; one specimen with spout on the shoulder 4. Globular, upright rim, flat or rounded base; two small vertical handles at the rim	1, 4. Smooth interior, barbotine exterior with a smoothed band under the rim and impressions between the two 2, 3. Smooth interior, rough exterior	1. rd 32, h 23 2. rd 9, h 7 3. h 9,5 4. rd 11, h 10-11	Georgieva 2012
37	Galatin	4600-4000	Flat	House	Coarse	1. Hemispherical bowl, convex rim, flat base; two flat lugs under the rim 2. Globular, flat base; two or four small lugs on the shoulder 3. Globular, flat base, upright rim; two vertical handles on the shoulder	1. Smooth interior, rough exterior 2-3. Smooth interior, barbotine exterior with a smoothed band under the rim and impressions between the two	1. rd 26, h 20 2-3. rd 15, h 15-20	Georgieva 2012
38	Devetaki	4500-4000	Cave		Coarse	Globular, upright rim, flat base; four small lugs on the shoulder or at mid-height	Smooth interior, barbotine exterior with a smoothed band under the rim	rd 12-15, h 15	Georgieva 2012
39	Golyamo Delchevo	4900-4300	Tell	Houses with ovens		Globular or biconical, flat base; no handles or lugs, applied pellets or impressed coils at mid-height or shoulder	Smooth interior/exterior or smooth interior, barbotine exterior with a smoothed band under the rim and at the base		Todorova H et al 1975
40	Petko Karavelovo	4900-4600	Tell	Houses with ovens	Medium-coarse, grog tempered, organic material	1. Globular or biconical, flat base, simple rim, lugs on belly 2. Bowl, hemispherical, simple rim, spout 3. Collared jar	Barbotine or smoothed exterior, smoothed interior, impressed, incised or grooved	1. wth 0.7, bth 1.5 2. wth 0.7 3. wth 0,8	Chohadzhiev 2017; present study
41	Avren-Bobata	4700-4300	Tell	Houses with ovens	Medium-coarse, grog tempered, organic material	1. Globular or biconical, flat base, simple rim 2. Wide belly and neck, simple rim, flat base, small vertical roll handles on upper part and small lugs above the belly	Smoothed exterior/interior	1. h 30, bd 30, wth 0.6-1 2. h >30, wth 1	Leshtakov P and Ivanova 2016; present study
42	Bezhanovo	4000-3700	Flat, on a river terrace	Above-ground house		1. Globular with restricted opening, upright rim, no handles 2. Ovoid body, upright rim, two vertical handles on the shoulder	Smoothed	1. rd 19-20 2. rd 21-24, maxd 30-33	Valentinova 2016
43	Dolno Dryanovo	4250-3700	Flat, rock-cut, mountain-ous			Globular or ovoid body, upright rim, two vertical handles on the shoulder			Todorova N 2016
44	Yagodina	4250-3700	Cave			Globular or ovoid body, upright rim, two vertical handles on the shoulder			Todorova N and Avramova 2016

Table 21.4. Summary of LNII/FN-Chalcolithic cooking pottery characteristics.

Fig. 21.6 LNII/FN-Chalcolithic cooking pottery wares from Dikili Tash. a hole mouthed vessel; b small sized collared jar; c stand (©Ecole française d'Athènes/Dikili Tash research project. a, b Ph. Collet; c C. Watroba).

Fig. 21.7 LNII/Chalcolithic cooking globular bowl from Petko Karavelovo (drawing and photo: after Chohadzhiev 2017, 32 Fig. 9).

constructed with wood and clay, and equipped with thermal structures; we studied vessels from three of them: House 10 (Chohadzhiev 2017; Chohadzhiev et al 2018), Features 154 and 155. The majority belongs to small and medium-sized globular-biconical pots with a thick flat base and simple rim, occasionally having small mastoid lugs on the belly (Fig. 21.7). Only one is a small-sized hemispherical bowl with simple rim and a cylindrical, obliquely cut spout under the rim, and a second preserves only the collared rim and not the body that could have been globular.

At Avren-Bobata, large rectangular houses have been investigated, equipped with thermal structures. We examined two vessels found near a large hearth in one of the houses (Leshtakov P and Ivanova 2016; Leshtakov P et al 2016, 2017, 2018). The first is a large sized hole-mouthed flat-based biconical-globular pot (similar to Fig. 21.7) and the second a flat-based pot with a wide belly, high neck, wide mouth with simple rim, small vertical roll handles on the upper part and small lugs above the belly.

Finally, we studied the cooking pots from a well-preserved house investigated in Dikili Tash, House 1, destroyed between 4350-4250 BC, and its surroundings (Darcque et al 2011, 2020). This is a rectangular building, constructed of wood and clay, and equipped with two thermal structures and platforms. More than 45 intact or almost intact vessels were found in its interior, and many more fragmented, 13 of which are regarded as cooking. The latter were located in several micro-contexts, some in relation to thermal structures and others not, pointing to their relation with various activity areas. With the exception of the small piriform collared jar mentioned above (Fig. 21.6b),[6] all other vessels belong typologically to a homogeneous group of hole-mouthed, globular, flat-based pots with simple rim, with four lugs, mastoid or knobbed, on the larger periphery of the belly, and/or

6 We did not take sample for petrographic analysis from this vase, as it is perfectly intact.

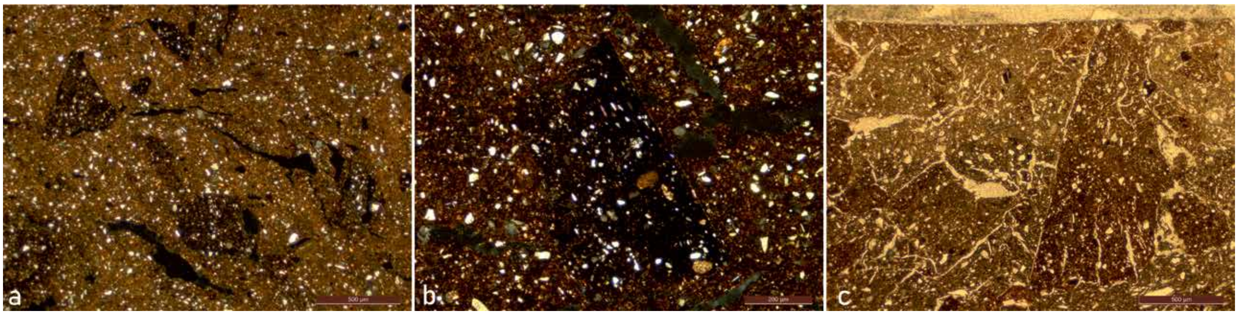

Fig. 21.8 Microphotographs of LNII/FN-Chalcolithic cooking pottery fabrics in thin section, tempered with grog and plant inclusions. a, b Petko Karavelovo (XP); c Avren (PPL) (© PlantCult Project, A. Dimoula).

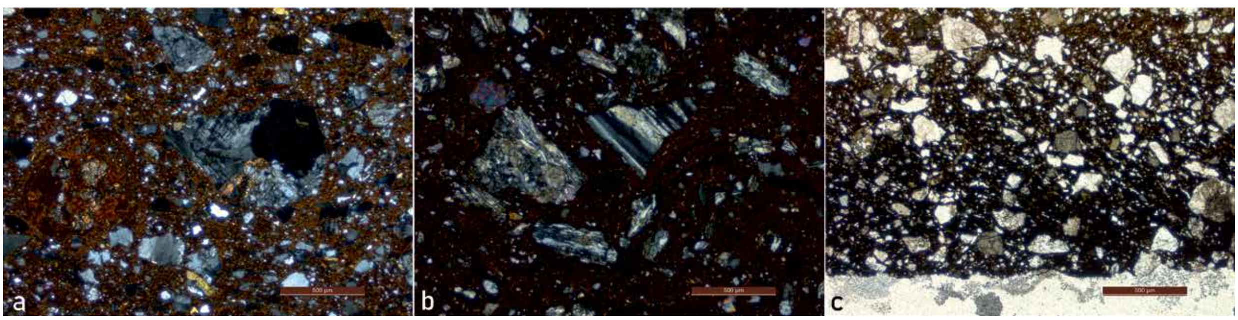

Fig. 21.9 Microphotographs of LNII/FN-Chalcolithic cooking pottery fabrics in thin section from Dikili Tash. a coarse, granodiorite inclusions (XP); b coarse, metamorphosed inclusions; c absorption of charred material in internal wall (PPL) (© PlantCult Project, A. Dimoula).

horizontal roll handles (Fig. 21.6a). Their bases are thick, as also is the wall in its largest periphery. Their sizes vary from small to medium-large (see Table 21.4) and their capacity between 1.5-8 l.

The results of the petrographic analysis of the cooking pot samples from the two sites in Bulgaria are quite similar. Both the Petko Karavelovo and the Avren-Bobata samples fall into single groups, medium to coarse grained, characterised by the addition of grog, i.e. crushed ceramics, in a rather fine-grained clay mass. Organic material is also present, in cases representing the deliberate addition of plant material, while the rare occurrence of shells, ostracods and foraminifera points to the river and marine deposits in the broader area of the sites. Both groups are considered as locally produced; rock fragments however are absent hindering a more precise geological characterization.

The Dikili Tash samples also belong to a single homogeneous fabric, which is identified as identical to the main local LN I fabric (Tsirtsoni and Yiouni 2002: Group 1). It is coarse-grained, non-calcareous and characterised by large-sized inclusions of igneous origin, mainly granodiorite fragments and others with micrographic texture, and their mineral constituents, silicates and hornblende (Fig. 21.9a). There is only one exception of a globular pot, which is typologically similar to others, but belongs to a completely different fabric, again coarse-grained, but including mica-schist fragments in a rather fine groundmass (Fig. 21.9b). This fabric is not identified within the previous LN I ones, but its composition refers to the geological setting of the site, though pointing to a different raw material source. Finally, it should be noted that both fabrics are characterised by the occasional presence of plant organic material in the clay mass. As for clay processing, the distribution of inclusions indicates the use of naturally coarse sediments for the majority of the samples, while only the individual sample exhibits the practice of tempering, evidenced by the presence of large subangular fragments in a fine clay mass. Similarly, vegetal inclusions are mainly natural occurrences, with only few examples pointing to possibly deliberate addition, based on their frequency and distribution.

The majority of the Petko Karavelovo samples have their exterior surface covered by barbotine up to their upper part, where there is a burnished band below the rim (Fig. 21.7). This surface treatment is very frequent in the area during the entire Chalcolithic period. Quite often the boundary between the two zones, the barbotine and burnished, is marked with a coil with impressions or incisions and/or a groove surrounding the vessel. The rest of the pots, as the ones from Avren-Bobata and Dikili

Tash, have coarsely burnished or smoothed exterior and interior. Firing temperatures appear to be low everywhere, although refiring due to destruction often confuses the image.

Similar is the problem with identifying use-wear traces for these sites. Fire destruction was severe, making almost impossible to establish if fire clouds are an effect of use or post-depositional. In most of the cases it is certain that the clouds are a result of fire destruction (e.g. indicated by the different colours of sherds mended to form complete pots). However, for few examples where sooting clouds concentrate on the base, the lower part and up to the mid-height of the vessel where the lugs are placed, it is possible that they comprise use-wear traces. The same accounts for the interior; in very few cases carbon deposits are observed in the bottom and lower walls of the pots. Finally, the majority of all the above pots we studied exhibit dark interior edge in thin section, something not observed on the exterior edges (Fig. 21.9c). This indicates repeated use of low liquid content permitting the penetration of charred material in the vessel wall (Skibo 2013).

After 4250 BC, evidence is scarce and habitational contexts like those described above are missing. At Dikili Tash, the remains of a Final Neolithic/Final Chalcolithic level (4200-3800/3700 BC) were unearthed immediately above the destruction layer of House 1, consisting of two deep pits and the surrounding floor, filled with a homogeneous fill of fragmented vessels, architectural debris, and bones, both burnt and unburned (Tsirtsoni and Malamidou 2015-2016). None of the vessels can be formally identified as cooking, but some of the retrieved globular pots with upright rim, or s-shaped jars or bowls with two vertical handles on the upper part, could be used for this purpose. The detailed technological analysis of this material is still in course. Similar vessels are reported from coeval contexts in sites from the areas of South and NW Bulgaria (Table 21.4). No securely dated sites exist in both Northern Greece and Bulgaria for the period between 3700 and 3600 BC.

21.6 Proto-Bronze and Early Bronze Age (EBA, ca 3600-2000 BC)

Entering the Early Bronze Age, substantial changes are observed in many aspects of material culture, and particularly in the morphological and technological characteristics of pottery as compared to the Neolithic/Chalcolithic. Unfortunately, the exact pace of these changes is not clear, due to the poor knowledge of assemblages from the previous centuries. Yet, in the EBA sites, either tells or flat, households appear to be the central units of social life in both northern Greece and Bulgaria (Andreou 2010). The majority of activities, including food preparation, appear to have taken place in house interiors, which were equipped with various types of thermal structures. Outer areas with hearths, pits or ditches are attested more rarely.

The early phases of the EBA, i.e EBA I (3300-2900 BC), are represented only in sites in eastern Macedonia and Bulgaria, while the intermediate “Proto-Bronze” stage (3600-3300 BC) is attested so far in the single example of Drama-Merdzhumekja in Bulgarian Thrace (Table 21.5). The majority of sites in both countries belong to the EBA II-III periods (2900-2000 BC). However, the vessel repertoire appears to be strikingly homogeneous in all subperiods. Thus, the commonest vessels are deep, open or wide-mouthed, with ovoid, conical, globular or s-profile shape and exclusively flat bases (Fig. 21.10a, b). Their rims are either simple vertical or outward and less frequently inward. They often feature one or two pairs of handles and/or lugs, placed on the shoulder or the belly, frequently joined by a coil with impressions or incisions. Such coils are decorative but would also aid handling, and are found even when handles or lugs are absent. Decoration with impressions or incisions is also found on the rim, while in Bulgaria rows of perforations below it are also common. Spouts are rare. The dimensions of the vessels cover a wide range, with rd between 10-50 cm and h equal to the rd or x1.5. Still, the majority appears to fall into the average of rd 20-30 cm, with the pots from Bulgaria referred to more frequently as elongated, also encountered in northern Greece. The second type of cooking pots in use, though not that common, are bowls, conical or hemispherical, with inward rim or s-profile and flat base (Fig. 21.10c).

Another type of cooking vessel from this period (after 2900 BC) is the shallow (h <10 cm), large in diameter (>40 cm) and flat based cooking dish (Fig. 21.10e). Such vessels commonly have a row of perforations below the rim, but plain unpierced specimens are also found, while they can exceptionally feature spouts. Interestingly they are found in sites in northern Greece but they do not seem to be found in Bulgaria. They are widely distributed in southern Greece as well, where they are usually mentioned as “baking pans” and connected with the so-called “cheese-pots” of the previous Final Neolithic period. Accordingly, they can be considered as a southern trend with limited diffusion to the North, but we cannot exclude the possibility of a “revival” of the even earlier local type of Neolithic cooking dish or a mixture of two (Dimoula et al 2022).

The technological features of EBA cooking pots appear to exhibit a respective homogeneity, although analytical data are generally lacking. Their fabrics are reported as coarse-medium grained with mineral inclusions and organic material. Their surface is commonly smoothed, less frequently coarsely burnished or left rough and rarely striated.

The cooking pots we studied from Archondiko (phase IV, end of 3rd mill BC) and Sokol (start of 3rd mill BC) follow the above general typological characteristics; the only exceptional shape being a rather small-sized jug from Sokol, with a flat base, obliquely cut mouth and a vertical strap handle (Fig. 21.10d). The results of the petrographic analysis of the Sokol cooking pots suggest two fabric

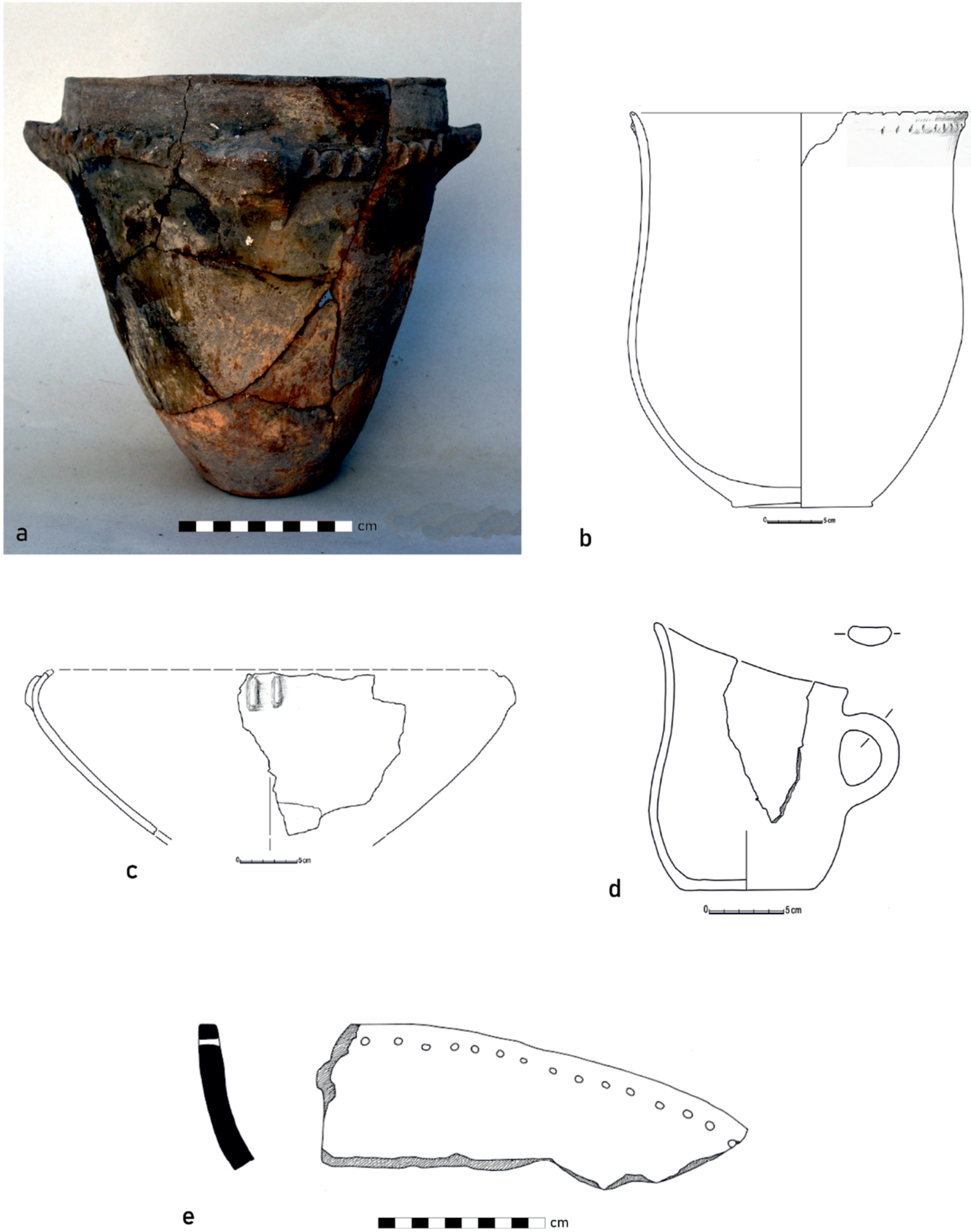

Fig. 21.10 EBA cooking pottery wares. a deep flat-based vessel from Archondiko; b deep flat-based vessel from Sokol; c bowl from Sokol; d jug from Sokol; e. cooking dish from Dikili Tash (© a PlantCult Project, A. Dimoula; b-d Sokol research project, N. Todorova and V. Petrova; e after Malamidou 2019, Planche 19).

Map No	Site	Date (BC)	Type of settlement	Contexts	Fabrics
7	Kovachevo	1st half of 3rd mill	Flat	No features	Coarse-medium
12	Karanovo phase VII	2500-2200	Tell	Houses	
16	Sitagroi phase IV	3300-2900	Tell	Long houses with thermal structures	Coarse, sand
16	Sitagroi phase Va	2900-2600		Apsidal building, thermal structures	Coarse, sand
16	Sitagroi phase Vb	2600-2300		Interior spaces	Coarse, sand
17	Dikili Tash EBA (ex-phase IIIA)	3300-2900	Tell	Interior and exterior spaces, thermal structures	1-2. Coarse, silicate, calcitic and organic inclusions 3. Coarse
17	Dikili Tash EBA (ex-phase IIIB)	2900-2300		Interior spaces, thermal structures	Coarse
27	Yunatsite	2900-2300	Tell	Buildings	Coarse
33	Drama Merdzhumekja (NW slope)	ca 2300-1900	Tell	Ditch	Coarse
33	Drama Merdzhumekja (NE slope)	3600-3200	Tell	Pits	Medium-coarse
45	Skala Sotiros	ca 2900-2000	Flat	Interior and exterior spaces, thermal structures	Coarse
46	Kryoneri	?-2400/ 2100	Flat, on a terrace	House debris	Coarse
47	Sidirokastro phase B	3300-2900	Cave	Interior spaces, thermal structures	Coarse
47	Sidirokastro phase A	2900-2600		Interior spaces, thermal structures	Coarse
48	Pentapolis phase I	?-2900-2500	Tell	Interior spaces, thermal structures	
48	Pentapolis phase II	2500-2100		Interior spaces, thermal structures	Coarse
49	Axiochori	3rd mill (no dates)	Tell	House debris, thermal structures	Coarse
50	Sindos	3100-2100	Flat	Pits	Coarse
51	Agios Athanasios	2490-2190	Flat, on natural hill	Interior and exterior spaces, thermal structures	Medium-coarse, single local fabric with igneous inclusions, low temperatures, one import
52	Mesimeriani Toumba	2200-2000	Tell	Interior spaces, thermal structures	Coarse-medium
53	Agios Mamas-Olynth Layer 18	2060-2010	Tell	Interior spaces, thermal structures	Coarse
54	Kastanas Layers 28-22	end 3rd mill	Tell	Interior spaces, thermal structures	Coarse
55	Perivolaki	3rd mill (no dates)	Tell	House debris	Coarse
56	Torone phases I-III	3rd mill (no dates)	Flat	Interior spaces, thermal structures	Coarse-medium

Table 21.5. Summary of Proto-Bronze and EBA cooking pottery characteristics.

Shapes	Wares/Decoration	Dimensions (cm)/ Capacities (l)	References
Conical, ovoid, handles under the rim, small lugs	Plastic bands, horizontal on rim or upper part	h 15, rd 15-30, bd 10	Kulov 2011
Ovoid, s-profile elongated, vertical handles on/under the rim or on body	Smoothed, plastic bands vertical or horseshoe-shaped	h 15-35, rd 15-25, bd 10-15	Hiller and Nikolov 2002; Nikolov 2011
Ovoid or conical body, flat base slightly incurving rim	Coarse burnishing, incisions on rim	rd 15-40/ 3-10	Sherratt 1986; Gardner 2003
Ovoid or conical body, flat base, handles or lugs	Smoothed or coarse burnishing, impressions or incisions or cordon on rim or shoulder	rd 15-40/ 3-10	Sherratt 1986; Gardner 2003
Ovoid cylindrical or conical body, incurving or outcurving rim, flat bases, handles or lugs	Smoothed or coarse burnishing, impressions-fingernail or dots, cordons, on rim or shoulder	rd 12-40/ 3-10	Sherratt 1986; Gardner 2003
1. Open conical, flat base, lugs under the rim 2. Restricted mouth, hemispherical, two lugs under the rim 3. Open, s-shaped with vertical handles	Smoothed	rd 20-25 cm	Malamidou 2019; Tsirtsoni 2016; Koukouli et al 2020; present study
1. Open conical, lugs under the rim 2. Restricted mouth, hemispherical, two lugs under the rim 3. Open or restricted, s-shaped with vertical handles 4. Pans, with or without perforations below rim	Smoothed or coarse burnishing; impressions or incisions on rim	rd 30-50	Malamidou 2019
Ovoid, s-profile, conical elongated, handles under the rim/ upper part	Smoothed, rough	h 25-55, rd 20-35, bd 10-15	Yunatsite vol. II, 2007
Conical, hemispherical elongated, handles on upper part	Smoothed	h 30, rd 25, bd 12	Lichardus et al 2001
Ovoid, conical, elongated, globular, tubular handles on rim, vertical handles on upper part	Smoothed, plastic bands horizontal, rows of impressions under the rim	h 20-40, rd 15-30, bd 8-12	Gleser and Thomas 2012
Ovoid, conical body, simple rim, flat base, vertical strap handles on belly			Papadopoulos et al 2001
Ovoid body, vertical rim, flat base, vertical strap handles on shoulder	Smoothed; impressions on rim		Malamidou 2016
1. Conical 2. Restricted mouth, globular or hemispherical	1. Smoothed; row of incisions on rim 2. Smoothed	1. rd 30, h 20-24 2. rd 7-20, h 7-12	Siros and Mitelesis 2016
Globular body, outward rim, no handles pres.	Smoothed; plastic band with impressions on rim		Siros and Mitelesis 2016
Rare-not specified			Grammenos 1981
Ovoid, flat base, vertical convex walls, two vertical strap handles below rim	Smoothed; impressed band under rim	rd 15, h 18	Grammenos 1981
1. Conical, ovoid body, simple or outward rim, flat base, ledge lugs o knobs on shoulder 2. Pans conical or hemispherical, pierced below rim	1. Smoothed or rough or coarse burnishing Impressions or incisions or cordon on rim or shoulder 2. Rough exterior, smoothed interior		Aslanis 1985
1. Ovoid, conical, globular, s-profile, simple or outward rim, vertical strap handles on belly, lugs on shoulder 2. Pan, plain	Smoothed or rough or coarse burnishing	1. rd 15-30 / 2.5-8.5 2. rd 40	Andreou 2000
1. S-profile, ovoid-globular body, outward rim, flat or discoid base, vertical strap or ellipsoid handles on rim and shoulder, lugs on belly 2. Ovoid body-tall neck, outward rim, flat base, vertical ellipsoid handles on body, lugs on belly 3. Ovoid body, inward rim, flat base 4. Conical body, flat base, pierced below rim, spout 5. Shallow, conical body, flat base, spout	Smoothed or burnished, rarely striated Incisions, impressions or plastic on or below rim or belly	1. rd 11-24, 24-40 / 0.5-6, 6-10 2. rd 13-52 / 1-8, 5-37 3. rd 14-19, 20-30, 32-42 / 1-7 4. h 15,5, rd 31.5 5. h 9.5	Mavroidi 2012
Ovoid, conical, globular body, outward or inward rim, flat base, horizontal handles or tongue lugs below rim, spout	Smoothed, rough, rarely striated Impressions or incisions on rim, cordon below	Different sizes and capacities, indicatively h 15-30, rd 20-30, bd 10	Grammenos and Kotsos 2002
1. Conical, ovoid, globular body, s-profile, vertical or outward rim, flat base, vertical handles, strap or roll, or tongue lugs on shoulder or belly, spout 2. Pans, plain or pierced below rim, spout	1. Smoothed, rough Impressions or incisions on rim, cordon below 2. Rough exterior, smoothed interior	1. Average rd 15-30, h 20-40 2. rd 40	Aslanis 1985; Hänsel and Aslanis 2010
1. Conical, ovoid, globular body, s-profile, vertical or outward or beveled rim, flat base, vertical handles or tongue lugs on shoulder 2. Pans pierced below rim	Smoothed, rough, rarely striated Impressions or incisions on rim, cordon on shoulder	rd up to 35	Aslanis 1985
1. Conical, ovoid, globular body, simple or outward rim, flat base, tongue or horn lugs o knobs on shoulder 2. Pans, plain or pierced below rim	1. Smoothed or rough or coarse burnishing Impressions or incisions on rim cordon on shoulder 2. Rough exterior, smoothed interior		Heurtley 1939; Aslanis 1985
1. Conical, ovoid body, s-profile, simple or outward rim, flat base, vertical strap handles or lugs on shoulder 2. Pans, plain or pierced below rim	1. Smoothed or rough or coarse burnishing Impressions or incisions on rim cordon on shoulder 2. Rough exterior, smoothed interior	Average rd 15-20, h 15-30, bd 10	Morris 2009/10

Map No	Site	Date (BC)	Type of settlement	Contexts	Fabrics
57	Kritsana	3rd mill (no dates)	Tell	House debris	Coarse
58	Archondiko phases III-IV	2135-1980	Tell	Interior spaces, thermal structures	Coarse-medium, one main and two minor local groups; high iron clays, metamorphic, igneous and sedimentary rock fragments, organic inclusions, porous, low temperatures
59	Kitros-Louloudia	3rd mill (no dates)	Flat	Houses, pits	Coarse
60	Servia	2900-2000	Flat	Pits, interior floors, yards	Coarse
61	Armenochori	3rd mill (no dates)	Tell	Interior and exterior spaces, thermal structures	Coarse
62	Sokol, level IV	3200-2600	Tell	Interior and exterior spaces, thermal structures	Coarse, two fabric groups, high iron clays, granitoid or sandstone, organic inclusions, low fired, <850°C
63	Nova Zagora	2500-2300	Flat	Interior and exterior spaces, thermal structures	Coarse-medium, mineral inclusions
63	Nova Zagora phases I-II	2400-2100	Tell		Coarse
64	Dyadovo levels XIV-IX	3100-2900	Tell		Coarse, local granitoid inclusions
64	Dyadovo levels I-II	2400-2100	Tell		Coarse
65	Ezero levels XIII-V	3100-2500	Tell		Coarse
65	Ezero levels I-III	2500-2200	Tell		Medium-coarse
66	Galabovo levels I-III	?2100-1900	Tell	House interiors	
67	Karasura Kaleto	3rd mill	Tell and periphery		Coarse
68	Cherna gora I	2300-2000	Enclosure	Dwelling -ditch	Coarse-medium
69	Sveti Kirilovo	2300-2000	Tell		Coarse
70	Dubene-Sarovka	1st half of 3rd mill	Flat	Houses	Coarse
71	Sozopol	mid 3rd mill	Flat, submerged	Posts	Coarse, mineral inclusions, shells
72	Kiten-Urdoviza	mid 3rd mill	Flat, submerged	Posts	Coarse-medium, mineral inclusions, shells

Table 21.5. continued.

Shapes	Wares/Decoration	Dimensions (cm)/ Capacities (l)	References
1. Conical, ovoid body, simple or outward rim, flat base 2. Pans conical or hemispherical, pierced below rim or simple	1. Smoothed or rough or coarse burnishing Impressions or incisions or cordon on rim or shoulder 2. Rough exterior, smoothed interior	2. rd 40	Heurtley 1939; Aslanis 1985
1. Conical and ovoid body, simple, inward or outward, or beveled rim, flat or disc base, vertical handles or tongue or horn-shaped lugs on shoulder 2. Hemispherical or s-profile bowls	Smoothed, rough, coarse burnishing, rarely striated Impressions or incisions on rim, cordon below	Average rd 10-20, 20-35, 35-50 bd 5-7, 8-12, 13-15, wth 0.5-1.2, bth 1-1.3 /1-20, 30-50	Deliopoulos 2014; Dimoula et al 2022b
Ovoid, conical body, simple rim, flat base, vertical strap handles on belly, knobs	Smoothed or coarse burnishing		Besios 2010
1. S-profile with globular body, ovoid with tall neck and vertical ellipsoid handles or ledge lugs, conical with simple or inward rim, flat base 2. Pans with curved base, conical body and spout, often pierced around the rim, internal ledge lug	1. Coarse burnishing, rough; impressions or incisions on rim, cordon below 2. Rough exterior, smooth interior for pans	1. Average rd 20-25 2. over 60	Ridley and Wardle 1979
1. Ovoid, globular, conical body, s-profile, simple or outward rim, flat base, vertical strap handles, horizontal tubular, tongue or disc lugs on shoulder 2. Pan with curved base and pierced below rim	Coarsely smoothed or burnished; incisions, impressions or plastic on rim and shoulder	1. h 17-28, 33-43 2. h 9	Heurtley 1939; Chrysostomou 1998
1. Ovoid, s-profile, flat base and simple flaring rim; row of holes below rim 2. Bowls, hemispherical with simple rim, conical with incurving rim and twin vertical elongated lugs 3. Jug, open, ovoid, flat base, obliquely cut mouth, simple flaring rim, vertical ellipsoid handle on shoulder and belly	Coarsely burnished exterior, well smoothed interior	1. h 33-35, rd 28-30, bd 12-15 2. h 15, rd 35 3. h 17, bd 8	Semmoto et al 2016; present study
Conical, ovoid body, s-profile, simple or outward rim, vertical handles or tongue or horn-shaped lugs	Smoothed, coarse burnishing, various plastic bands on rim or shoulders	rd 20-30	Kancheva-Russeva and Leshtakov 2008
Ovoid, s-profile, vertical handles on shoulders	Smoothed or burnished upper part; coarse or rarely striated – lower; plastic bands		Leshtakov 1992
Ovoid, s-profile, globular or ovoid body with cylindrical neck	Plastic bands, incisions on rim, row of perfora-tions under the rim	h 30-35, rd 22-35, bd 10-15	Semmoto 2008; Kamuro 2005; Semmoto et al 2015
Ovoid, s-profile elongated, small vertical handles on the rim	Smoothed or burnished upper part; coarse or rarely striated – lower; plastic bands		Leshtakov 1992
Ovoid, s-profile	Smoothed; plastic bands, incisions on rim, row of perforations under the rim	h 15-20, rd 15-20, bd 10	Georgiev et al 1979
Ovoid, s-profile elongated, small vertical handles on rim, lugs	Smoothed or burnished upper part, coarse or rarely striated lower part, plastic bands, knobs	h 25-35 (55), rd 20-25 (35), bd 10-15	Leshtakov 1999
Ovoid, conical elongated, cylindrical neck, vertical handles or lugs under the rim or on shoulders; handles on body	Smoothed, plastic band vertical or horseshoe-shaped	h 15/20 -45/50, rd 15-35, bd 7-15	Leshtakov 1993, 2002, 2015
Ovoid, conical, elongated, small tongue lugs	Plastic bands vertical, horizontal or horseshoe-shaped	h 25, rd 20-30, bd 10	Georgieva 1994
Elongated ovoid, with neck, handles in the middle	Smoothed, plastic bands, horizontal under the rim or vertical, small lugs	h 30-35, rd 12-2, bd 8-12	Leshtakov 2006
Ovoid with cylindrical neck	Smoothed upper part, coarse lower, horizontal plastic band in the middle		Leshtakov 1992
Conical, ovoid, elongated, short neck, handles under shoulders	Smoothed	h 20-35, rd 18-22, bd 10-12	Nikolova 1999
Open-mouth, s-profile		h 20, rd 20-30, bd 10	Draganov 1998; Dimitrov et al 2020
Conical, s-profile, handles on shoulders	Single/double rows of impressions or strokes under rim or in the middle, plastic bands horizontal	h 15-40, rd 20-30, bd 10-15	Leshtakov 1994; Dimitrov et al 2020

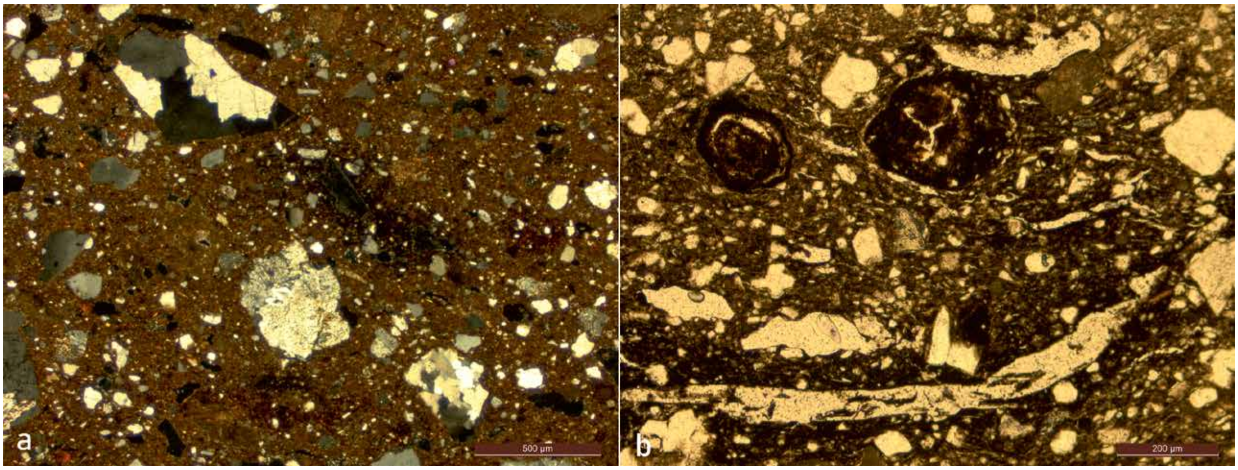

Fig. 21.11 Microphotographs of EBA cooking pottery fabrics in thin section from Sokol. a coarse, granitoid and sandstone inclusions with organic material (XP); b plant inclusions (PPL) (© PlantCult Project, A. Dimoula).

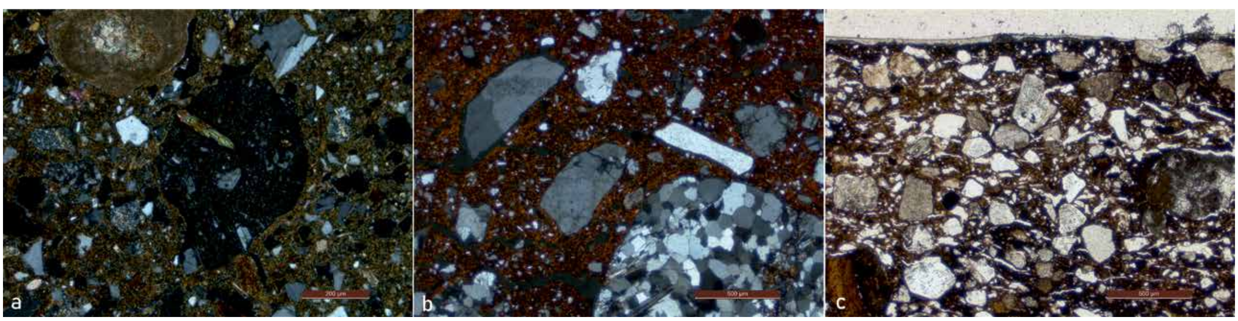

Fig. 21.12 Microphotographs of EBA cooking pottery fabrics in thin section from Archondiko. a coarse, igneous inclusions (XP); b mineral temper (XP); c absorption of charred material in internal wall (PPL) (© PlantCult Project, A. Dimoula).

groups, characterized by coarse-grained high iron content clays[7] tempered with mineral and organic inclusions, as indicated by their shape and distribution. These comprise granitoid rock fragments and/or sandstone together with plant stems or seeds. Such rock formations are located in the hilly environment of the site (Leshtakov K et al 2019), though pointing to two different raw material sources.

The results from Archondiko also point to the use of coarse-grained clays with a high iron content and inclusions comprising altered metamorphic and igneous rock fragments and their mineral constituents, together with organic material, shells and plant parts (Dimoula et al 2022b). However, these probably comprise natural sediments encountered in the geological environment of the site, where fluvial and torrential systems transport and mix different deposits with marine material (Ghilardi et al 2008). In minor fabric groups the processing of natural sediments by either sieving or tempering is evidenced. The presence of different fabrics indicates the use of different clay sources or/and the limited circulation of cooking pots within a broader region.

Both the Archondiko and Sokol pots were built with the coiling technique, while drawing should have been practiced to join the coils, as indicated by the orientation of elongated inclusions observed in many samples, parallel to vessel walls. The pots were fired in mixed to reduced conditions and relatively low temperatures (<750 °C) with short firing duration, as indicated by the common presence of gray cores in the samples.

Although fire traces are frequently mentioned in the literature on EBA cooking pots, their exact location on the vessel is rarely known. Use-wear analysis from Archondiko Phase III cooking pots suggests that they could had been used over the upper opening of U-shaped hearths attested on the site (see Papadopoulou et al this volume), while their interior often preserves organic deposits on the rim or on the belly, indicating respectively liquid foods, i.e. soups, or thicker foods, i.e.

7 The results of chemical analysis, via EDXRF, of EBA pottery samples from Sokol, have shown that CaO content is below 3 wt % for the majority of the samples (Semmoto et al 2016, 156-157, Fig. 4.2).

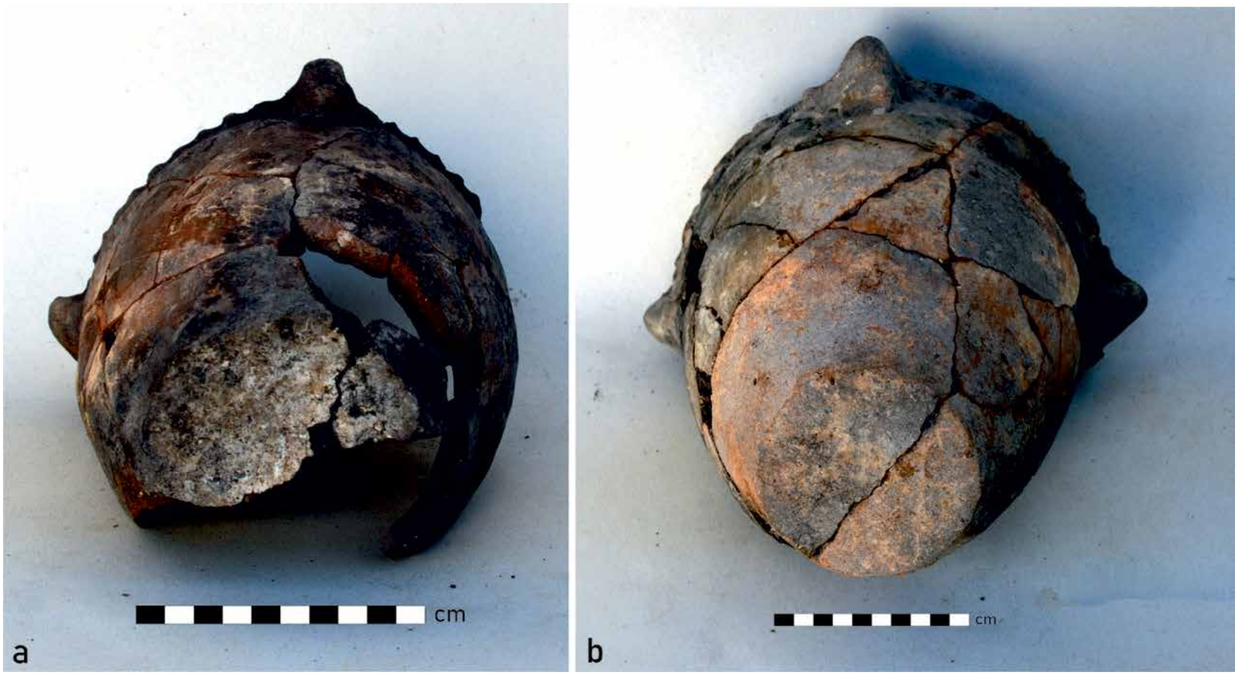

Fig. 21.13 EBA cooking pottery use-wear traces from Archondiko. a exterior, base with sooting clouds; b exterior, oxidized base (© PlantCult Project, A. Dimoula).

porridges (Deliopoulos et al 2011, 225-226). Liquid foods and vetch seeds are reported as contents of the pots found on and around the hearth of the contemporaneous House 1 in Agios Mamas-Olynth (Hänsel and Aslanis 2010, 73-87). As for the capacities of the vessels the majority varies between 1-10 l, fewer between 10-20 l and rarely between 30-50 l.

Evidence is less clear for phase IV of Archondiko, as pots are heavily affected by the fire that destroyed the houses. The lower part and base of the vessels are either oxidized or have sooting clouds, indicating that they were either used among fuel, where high temperatures are developed, or fire was placed below the base of the vessels and clouds were formed (see Dimoula et al 2020) (Fig. 21.13a, b). In the upper part, sooting clouds are scattered on the vessel belly and area below the rim, including handles and coils. The Sokol samples are even more severely affected by fire destruction. They have extensive sooting clouds alternating with oxidized areas on the exterior surfaces, while the interior surface is commonly almost black.

Under the microscope the majority of the samples from both sites have a dark internal margin, pointing to the penetration of charred elements in the vessel wall (Fig. 21.12c). This has been considered as a result of cooking with medium quantity of liquid (Skibo 2013, 96-98). More particularly, food particles in wet conditions penetrate the unslipped porous surface of the vessel and are subsequently charred after continuous use, mainly through simmering or the preparation of thick dishes, where liquid evaporates. On the contrary, the internal surfaces of the bowls from Sokol are completely clean of such traces, pointing to other functions or other cooking methods, such as boiling.

21.7 Middle Bronze Age (MBA, ca 2000-1600 BC)

Archaeological evidence on the MBA habitation in northern Greece and Bulgaria is rather limited. Scarcity of evidence is more pronounced in Eastern Macedonia and Thrace, whereas in Central and Western Macedonia several sites founded at the end of the EBA are occupied throughout to the LBA period. Coastline sites rise as nodes in Aegean and Balkan networks, facilitating the introduction of wheel-made pottery from the South (Aslanis 2014). Food preparation activities continue to take place mostly in the interior of houses, without again excluding outer areas.

The typological and technological characteristics of cooking pots (Table 21.6) follow the EBA tradition of the coarse flat based handled pithoid jars, to which some coarse bowls and jugs are occasionally added (Aslanis 2017; Deliopoulos et al 2011). By contrast, no cooking dishes are reported. But this period sees also the introduction of a new cooking pot type, the pyraunos, i.e. a deep vessel with attached pedestal with openings for air circulation (see Fig. 21.16a), under which fuel is placed (Hochstetter 1984; Morris 2009/2010). Our study

Map No	Site	Date (BC)	Type of settlement	Contexts	Fabrics	Shapes	Wares / Decoration	Dimensions (cm)/ Capacities (l)	References
53	Agios Mamas Layers 17-11	2025-1725	Tell	Interior spaces, thermal structures	Coarse-medium	1. Conical, ovoid, globular body, s-profile, vertical or outward rim, flat base, vertical handles, strap or roll, on shoulder or belly, lugs or knobs on rim or shoulder, spouts 2. Pyraunos fragment	Smoothed, rough, rarely striated Impressions or incisions or cordon on rim or shoulder	Average rd 10-30	Aslanis 2017; Horejs 2007
56	Torone phase IV	MBA (no dates)	Flat	Interior spaces, thermal structures	Coarse	1. Ovoid body, funneled rim, vertical strap handles 2. Pyraunos, ovoid body, funnelled rim, curved base, two horizontal roll handles on shoulder, pedestal attached below handles	Smoothed, impressed cordon on shoulder	h 35.5, rd 25.6	Morris 2009/10
58	Archondiko phase II	2015-1890	Tell	Interior spaces, thermal structures	Coarse-medium	Conical or ovoid body, simple, inward or outward, or bevelled rim, flat or disc base, vertical handles or tongue or horn-shaped lugs on shoulder	Smoothed, rough, coarse burnishing, rarely striated Impressions or incisions on rim, cordon below	Average rd 10-20, 20-35, 35-50 bd 5-7, 8-12, 13-15/ 1-20, 30-50	Deliopoulos 2014
73	Toumba Thessaloniki Layers 14-9	ca 2000-1700	Tell	Exterior areas	Coarse-medium	1. Ovoid body, outward rim, two vertical strap handles below rim 2. S-profile bowls	Smoothed, burnished	rd 20-30	Psaraki and Andreou 2010
74	Valtos-Leptokarya	1885-1695	Flat	Interior and exterior spaces	Coarse, single fabric, low iron clays, metamorphosed, igneous and organic inclusions, oxidising conditions	1. Ovoid body, funneled rim, two vertical strap handles, two double mastoid lugs on shoulder 2. Bowl with globular body, outward rim, flat base, tongue lugs on shoulder 3. Jug with ovoid body, flat base, vertical strap handle on rim and belly	Well smoothed	1. pr. h 20, rd 20/ 3-6 2. h 11, rd 26/ 2-3 3. h 20, rd 12 /1.5-2	Dimoula et al 2022c
75	Razkopanica	end 3rd-start 2nd mill	Tell	Houses; exterior spaces	Coarse	Conical, ovoid, ovoid with neck, S-profile; handles under the rim on neck or on shoulder	Horizontal plastic bands	h 15-20/60-65 bd 7-9/15-18 rd 15-20/20-35	Detev 1950, 1981

Table 21.6. Summary of MBA cooking pottery characteristics.

included the cooking pot assemblage from an MBA house in Valtos Leptokarya in Pieria (Poulaki-Pantermali et al 2007). This comprises cooking jars, bowls and jugs (Fig. 21.14), while the typical in Macedonia pithoid jar (see Fig. 21.10a) appears to be absent (Dimoula et al 2022c). The jar is ovoid with funneled rim and has a pair of vertical strap handles alternating with double mastoid lugs on the shoulder (Fig. 21.14a). The bowl is s-profile with large tongue lugs on the shoulder, while the jug has ovoid body and flat and thick base (Fig. 21.14b, c). Their capacity varies from 1.5 to 6l. Such types of vessels occur in coarse fabrics in contemporary sites in Macedonia (Aslanis 2017; Psaraki and Andreou 2010), but are also widely present at sites in Thessaly (Maran 1992; Hanschman 1981).

The petrographic analysis of the above pots points to the use of a single recipe, with raw materials deriving from the broader environment of the site (Dimoula et al 2022c). Fabrics are coarse grained, with high iron content clays tempered with mineral and occasionally organic material. Vessels are made with the coiling technique and their surfaces are well smoothed, without any decorative elements. They are fired in rather homogeneous oxidizing firing conditions, but in different firing temperatures, below and above 850 °C. As for their use-wear traces, the vessels are heavily damaged by fire destruction and are generally characterized by oxidized bases and sooting clouds developed on the belly, handles and rims. This could tentatively point to a use among fuel. Thin sections of the jar and bowl have dark internal margins, indicating cooking of thick liquid foods, in contrast to the jug sections that point to boiling.

21.8 Late Bronze Age (LBA, ca 1600-1100 BC)

In the Late Bronze Age, and especially after the mid–2nd mill BC, evidence of habitation in northern Greece is abundant, with the tell settlement supported by terraces being the dominant type (Andreou 2014). Intra-site organization comprises building complexes separated by streets and small courtyards; thermal structures are found in both interiors and exteriors. In southern Bulgaria, lower mounds are encountered with buildings comprising massive stone structures, as well as flat hilltop sites; flat sites in plains are more rare, probably due to problems of conservation or archaeological recognition (Table 21.7). A significant difference for both regions, in comparison to the previous periods, is the presence of spaces and vessels designed to store large quantities of foodstuff. Finally, another important aspect is the introduction and adaptation of Mycenaean type pottery, pointing to diverse communication ways with southern Greece (Andreou 2003; Jung 2003).

Cooking pots (Table 21.7), especially in the early phases, continue the previous traditions of the pithoid flat

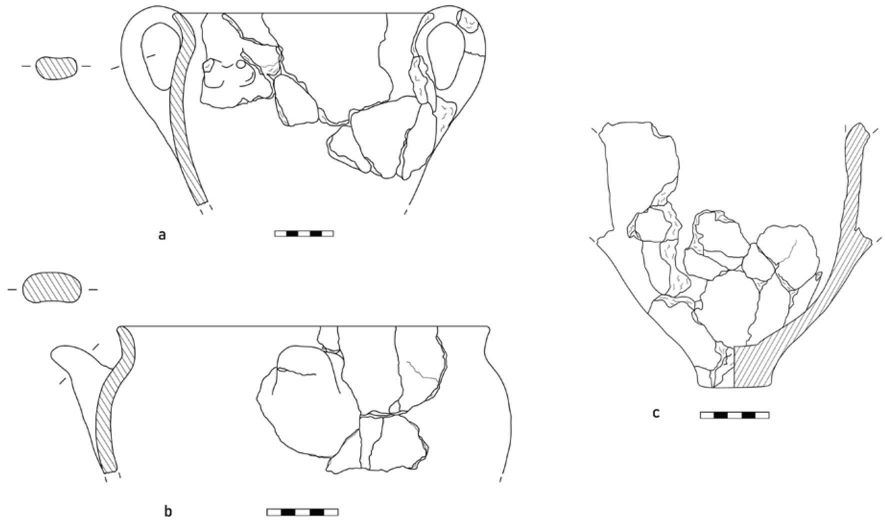

Fig. 21.14 MBA cooking pottery wares from Valtos-Leptokarya. a jar; b bowl; c jug (© PlantCult Project, D. Chondrou).

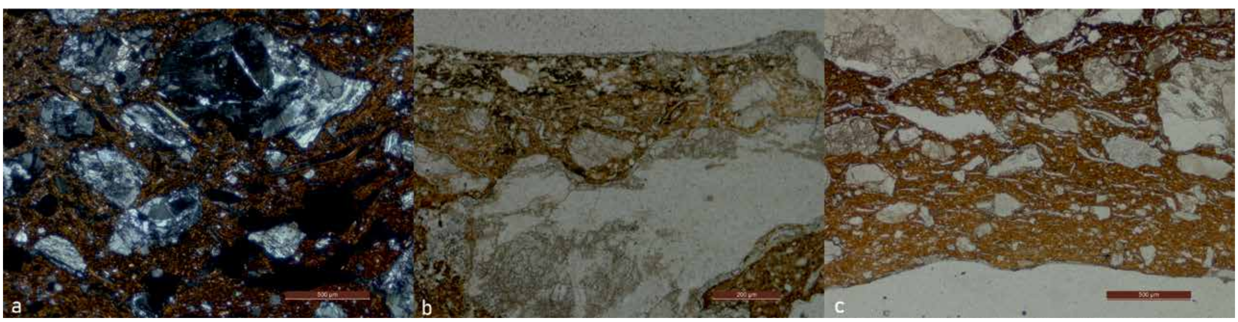

Fig. 21.15 Microphotographs of MBA cooking pottery fabrics in thin section from Valtos-Leptokarya. a mineral and organic temper (XP); b absorption of charred material in internal wall (PPL); c absence of absorption of charred material in internal wall (PPL) (© PlantCult Project, A. Dimoula).

based handled ovoid or conical vessels (Malamidou 2019; Deliopoulos et al 2011, 227), but in later phases the majority are wide-mouthed, with ovoid or globular body, s-profile, outward rim or low neck, and flat or curved base (Hochstetter 1984, 121-136; Horejs 2005, 72-74; 2007, 129) (Fig. 21.16b). They often feature vertical strap or roll handles attached on the rim, shoulder or belly. Decoration is again limited to impressed or incised patterns on plastic coils around or below the rim, and very rarely other elements. Vessel sizes vary from medium to large (average rd 15-30, 30-50 cm), and accordingly their capacity (1-15 to 40 l). Apart from the above handmade cooking pots, there are scant examples of wheel thrown ones, belonging to the late LBA phases of Toumba Thessaloniki and Kastanas (Andreou 2009; Jung 2003). They are either narrow or wide mouthed with globular body, funneled rim, horizontal handles and flat base. Pyraunoi represent up to 15% of cooking pot assemblages.[8] The vessels have similar characteristics to the jars described above, while the pedestal acquires different forms (conical, cylindrical or bell-shaped: Horejs 2007, Tafeln 78, 36, 152; Leshtakov 2019) and is attached to different parts of the body (shoulder, belly or lower part of the vessel: Hochstetter 1984, Tafeln 16, 45, 102) (Fig. 21.16a). The central opening is mostly arched, but generally the shape, size and placement of the openings on the pedestal walls vary. Pyraunoi are commonly large vessels (average rd 20-50 cm) with large capacity 10-40 l.

The third type of LBA cooking pots, met in considerably lower frequency than the previous types, is the shallow cooking dish.[9] At Archondiko such vessels bear perforations under the rim, like those of the EBA (Fig. 21.16c). LBA cooking dishes have thick flat bases and short walls, while their sizes vary from small to large (rd 10-40 cm) with low capacity (1-5 l). Finally, there are extremely rare examples of tripod handled cooking pots (a Southern Greek trend), with a globular body and curved

8 E.g. in Agios Mamas roughly 1500 jars and 250 pyraunoi are published, while in Archondiko 125 jars and 20 pyraunoi (Horejs 2005; Deliopoulos 2014).

9 It represents roughly 1% of the cooking pot assemblage in Agios Mamas, reaching 5% in Kastanas (Horejs 2005; Hochstetter 1984).

Map No	Site	Date (BC)	Type of settlement	Contexts	Fabrics	Shapes	Wares / Decoration	Dimensions (cm)/ Capacities (l)	References
17	Dikili Tash LBA (ex-phase IV)	1600-1100	Tell	Apsidal building with hearth	Coarse	1. Conical or ovoid body, simple rim, two vertical roll handles on the upper part 2. Ovoid body, outward rim, flat base, vertical or horizontal handles, strap or roll or crescent shaped, or knobs below rim 3. Dish asymmetrical, closed at one side, basket-handle	1-2. Smoothed; Impressed or incised decoration or cordon below rim and/or shoulder or belly, plastic elements or grooved, often in combination 3. Roughly smoothed	1. rd 30-50 2. various dimensions, a complete example rd 20, h 23 3. bd 54x59	Malamidou 2019
28	Dimitra	1400-1050	Tell	Interior spaces	Coarse	Ovoid body, simple rim, flat base, two vertical strap handles on shoulder	Smoothed, rough; impressed		Grammenos 1997
76	Stathmos Angistas	1200-1000	Tell	Interior spaces	Coarse	Ovoid or globular body, outward rim, two vertical roll handles or tongue lugs on shoulder	Rough; impressed on rim		Koukouli-Chrysanthaki 1980
52	Mesimeriani Toumba, phases 3-4	1674-1115	Tell	Apsidal building	Coarse	1. Ovoid or conical body, flat base, outward rim, handles or lugs below rim 2. Bowls conical with flat base and inward rim	Smoothed		Grammenos and Kotsos 2002
53	Agios Mamas-Olynth Layers 10-2	1600-1200	Tell	Interior spaces, thermal structures	Coarse and porous; different fabrics for jars and pyraunoi	1. Ovoid or globular body, narrow-mouthed, simple or outward rim 2. Ovoid or globular or conical body, wide-mouthed, s-profile, outward rim or funnelled, rarely simple or inward, two vertical or horizontal, strap or roll handles, or tongue lugs or knobs on upper part or belly 3. Pyraunos, s-profile or narrow mouthed, cylindrical or curved pedestal 4. Tripod, globular body, simple or outward rim, curved base, two vertical ellipsoid handles 5. Baking pans	Smoothed or rough; impressed or incised or cordon on rim and below	1-2. Average rd 15-30-40 3. h 35-39, rd 18-26, pedestal opening 12x10 4. rd 12	Horejs 2007
54	Kastanas Layers 19-12	1600-1100	Tell	Interior spaces, thermal structures, external areas-court-yards	Coarse Wheel-made examples	1. Globular or ovoid, wide mouth, s-profile or conical neck, flat base, vertical or horizontal handles, strap or roll, below rim or belly, tongue lugs or mastoid or knobs or crescent 2. Globular body, narrow mouth, low neck, simple or outward rim, flat or curved base 3. Pyraunos, ovoid or globular body, s-profile, simple or outward rim, vertical handles, roll or strap, on shoulder, or tongue lugs 4. Pans, simple rim	Smoothed, rarely burnished; impressions or incisions or cordon on upper part		Hochstetter 1984; Jung 2002
58	Archondiko Phase I	1510-1400	Tell	Interior spaces	Coarse-medium,	1. Conical or ovoid body, simple or outward rim, disc or flat base, rarely handles or lugs below rim or on belly 2. Pyraunoi, conical or ovoid body, simple or outward rim, flat or curved base, only tongue lugs 3. Pans pierced below rim 4. Bowls, hemispherical or s-profile, simple or outward rim, flat base, handles or lugs	Smoothed or rough, rarely burnished Impressions or incisions or cordon on rim or upper part	1. Average rd 26-40 or 10-28/ 15-40 or 1-15, max. 70 2. rd 22-24, h 26-28, ped d 28-30, h 30 or rd 48-53, h 45, ped d 55-60, h 35/ 10-20, max 40 3. rd 14-22/ 1.5 4. rd 15-46/ 1.5-20	Deliopoulos 2014
73	Toumba Thessaloniki Layers 5-4	1300-1150	Tell	Interior and exterior spaces, thermal structures	Coarse, three local fabric groups, ultrabasic-pyrox-enites, altered igneous-gabbro, acid-intermediate metamorphic igneous inclusions, oxidised or mixed conditions, short duration, low firing temperatures <750°C; different fabrics for jars, pyraunoi and pans; wheel made examples	1. Ovoid, globular, conical body, s-profile, simple, outward or funnelled rim, one or two vertical roll or strap handles, or tongue lugs on upper part, flat or curved base 2. Pyraunos, ovoid body, funnelled rim 3. Pans, flat base, simple rim	Smoothed, rough, rarely burnished; incised, impressed, grooved, cordon	1. rd 10-20-40 2. rd 30-40 3. rd 30-40	Kiriatzi 2000
77	Assiros Phases 9-5	1350-1050	Tell	Interior spaces, thermal structures	Coarse, smoothed, cordon	1. Globular or conical body, wide or narrow mouth, flat base, simple rim, one or two vertical roll handles 2. Pyraunos, globular or conical body, flat or curved base, simple rim, vertical handles or flat lugs below rim	Smoothed or rough; incisions or impressions or cordon on upper part	rd 10-20	Wardle et al 1980

Map No	Site	Date (BC)	Type of settlement	Contexts	Fabrics	Shapes	Wares / Decoration	Dimensions (cm)/ Capacities (l)	References
78	Angelochori Phase II	1495-1290	Tell	Interior and exterior spaces, thermal structures	Coarse, two fabrics, non-calcareous, igneous rocks or schists-phyllites, different fabrics for pyraunoi and jars, import, different temperatures	1. Conical or ovoid, simple flat rim, narrow flat or curved base, handles but more frequently large lugs on the upper part. 2. Pyraunoi, the above accompanied by a pedestal with openings, conical or bell shaped, or slab legs. 3. Globular, s-profile, low neck, outward rim, flat or curved base	1. Smoothed, rough 2. Smoothed, rough, plastic decoration around pedestal opening 3. Well smoothed, burnished	1. rd 20-40, bd 5, wth 1-1.3, bth 1.5-2.5 2. rd 15-20, wth 0.5-0.8	Dimoula et al 2022b
79	Rema Xydias	1489-1296	Flat	Apsidal building, external areas, enclosures	Coarse, two fabrics, low iron content, high grade metamorphic-gneiss, schist, serpentinite, and igneous fragments, organic material, oxidised conditions, different temperatures	1. Ovoid body, simple flat rim, narrow flat or curved base, two vertical strap handles or lugs 2. Tripods or flat-based jars, globular body, outward rim, concave neck, vertical strap handles, some have leg attachment points 3. Pyraunoi, ovoid or globular body, pointed or curved base, simple rim or concave neck, vertical strap handles, pedestal	Smoothed exterior, better smoothed interior	1. h 21-33, rd 21-24, wth 0.5-1 / 3-13 2. h 15-20, rd 18-20, wth 0.3-0.6 / 3-6 3. h 29-32, rd 18-25, wth 0.5-1 / 5-15	Dimoula et al 2022c
80	Pigi Artemidos	1390-1100	Flat	External structures, architectur-al remains	Coarse, same as Rema Xydias, import from Thessaly	Same as Rema Xydias	Same as Rema Xydias	Same as Rema Xydias	Dimoula et al 2022c
81	Trimpina	1600-1400	Flat	Pits	Coarse, same as Rema Xydias, import	1. Globular, s-profile or low neck, outward rim 2. Wheel-thrown globular body, funnelled rim, vertical cylindrical handle on shoulder 3. Pyraunos, ovoid body, outward rim, vertical grooved handle, curved pedestal	Same as Rema Xydias	Same as Rema Xydias	Dimoula et al 2022c
82	Kamenska Cuka	1400-1100		Stone building	?	Elongated ovoid, lugs		h 25-30, bd 10, rd 15	Stefanovich and Bankoff 1998
83	Koprivlen Phase 1-2	1500-1200	Flat	Dwellings	Coarse, rock fragments, grog, organics	Elongated s-profile; ovoid with short wide neck; two handles on the widest part of the body, lugs	Smoothed, intentionally coarse, notches or impressions on or under the rim, plastic horizontal bands	h 20-50, rd 20-40, bd 10	Alexandrov 2002
84	Zaportite sai	LBA (no dates)	Flat		Coarse-medium	Ovoid elongated; S-profile elongated	Smoothed, plastic bands horizontal	rd 15-20/ 25-30	Иванова, Тодорова 2008
85	Vratitsa	LBA (no dates)	Flat	No features	Coarse	1. Ovoid with short neck, elongated ovoid; S-profile-elongated; 2. Pyraunoi	Well smoothed outside, uneven inner surface; Plastic bands – various types, horse-shoe	1. rd 10-12/ 20-25 / 35 2. rd 30-35	Hristova 2011; Leshtakov 2019
86	Ada tepe	1500-1100	Hill-top	Houses	Coarse	1. Ovoid with short neck; elongated s-profile; 2. Pyraunoi	Smoothed, rarely plastic bands	rd 20-40, bd 10-12 h 25-30;	Nikov et al 2018; Horejs 2017; Leshtakov 2019
87	Kush kaya	1500-1200	Hill-top	Houses	Coarse	Kitchen ware – mentioned not described			Popov 2009; Popov et al 2018
88	Tatul	LBA (no dates)	Peak sanctuary	Thermal features	Coarse	Pyraunoi, handles on the upper part	Smoothed, plastic bands	rd 35 -60, h 40 <10	Овчаров и др. 2008; Leshtakov 2019
89	Chokoba 18A	1700-1300			Coarse, tempered, non-calcareous clays with igneous inclusions, plant material, firing below 800 °C	1. Ovoid or conical jars, flaring or simple rim, tongue lugs, crescent shaped handles 2. Pyraunoi with bell-shaped or conical pedestal	Smoothed or coarsely burnished exterior, smoothed interior, plastic, impressions or incisions		Leshtakov 2010, 2011, 2019; Leshtakov et al 2019; present study

Table 21.7. Summary of LBA cooking pottery characteristics.

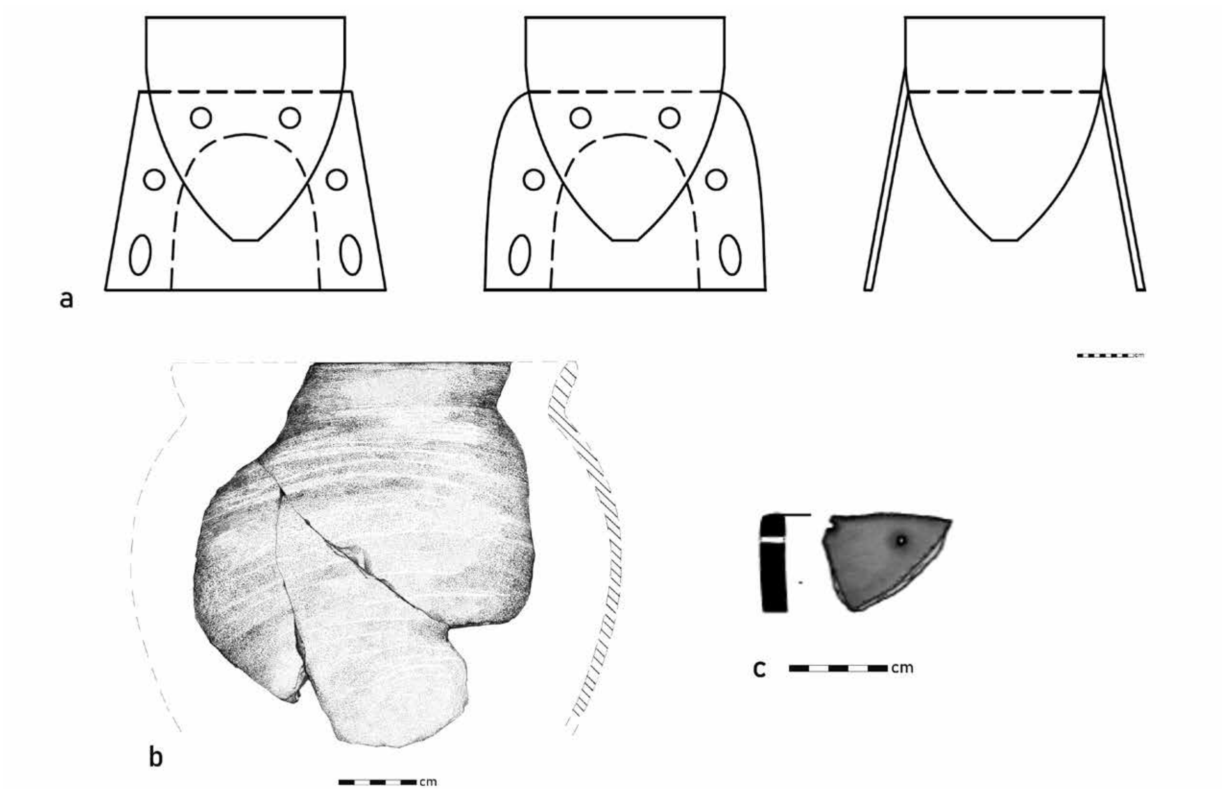

Fig. 21.16 LBA cooking pottery wares. a pyraunoi with different pedestals from Angelochori; b globular jar from Angelochori; c cooking dish from Archondiko (© a PlantCult Project, A. Dimoula; b Angelochori research project, E. Stefani; c after Deliopoulos 2014, Plate 148A).

base; there are also mentions of bowls used for cooking. The latter are flat based, conical, hemispherical or with an s-profile featuring handles or lugs.

The cooking vessels we studied from Angelochori (Phase II) derive from the interior and exterior spaces of two habitation units (A and D), the first preserving two thermal structures (Stefani 2010, 169, 140-141). Our study identified two types of cooking pots equally represented in all spaces (Dimoula et al 2022b). The first is pyraunoi, consisting of an ovoid or conical vessel, with a flat on top rim, handles or large lugs placed underneath, and a narrow flat or curved base, accompanied by a pedestal attached below the handles. Three types of pedestals were identified (Fig. 21.16a): the first and second have conical or bell shape, they are equipped with a central arched opening and the walls are pierced with small openings, circular or ellipsoid in shape. The third has the form of two slab legs (width 12 cm) attached to the periphery of the vessel. The only decoration met is plastic motifs surrounding the central opening. These vessels are large-sized with rim diameter varying between 20-40 cm. The second type of cooking vessel identified at Angelochori is that of a globular jar, s-profile or with a low neck and outward rim and flat or curved base (Fig. 21.16b). These are smaller in size vessels with rim diameter 15-20 cm and apparently smaller capacity.

Roughly contemporary to Angelochori is the flat site of Chokoba 18A in the Thracian plain, featuring shallow dug-out structures with thermal structures (Leshtakov K and Tsirtsoni 2016; Leshtakov K 2010, 2011). The cooking pots studied are either ovoid or conical with flaring or simple rim, below which a plastic coil with impressions or incisions is frequently applied. Crescent shaped handles are met, as well as tongue lugs, even in the interior of vessels. The same types of vessels are sometimes supported by an attached pedestal, bell-shaped or conical, with arched opening and circular holes. As at Angelochori, there are cases where plastic motifs adorn the pedestal's central opening (Fig. 21.17).

Quite different is the image acquired from the three sites studied in the coastal region of Macedonian Olympus (Dimoula et al 2022c), covering the entire LBA. The earliest samples come from two pits in the site of Trimpina (Koulidou et al 2012) and include two types, jars and pyraunoi (Fig. 21.18). The handmade jars are wide mouthed with globular body, s-profile or with low neck. In addition, a wheel thrown cooking jar was found, with globular body, funneled rim and a vertical cylindrical handle on

Fig. 21.17 LBA pyraunoi from Chokoba 18A. a part of pedestal with plastic decoration around the central opening; b part of pedestal with ventilation holes (© PlantCult Project, A. Dimoula).

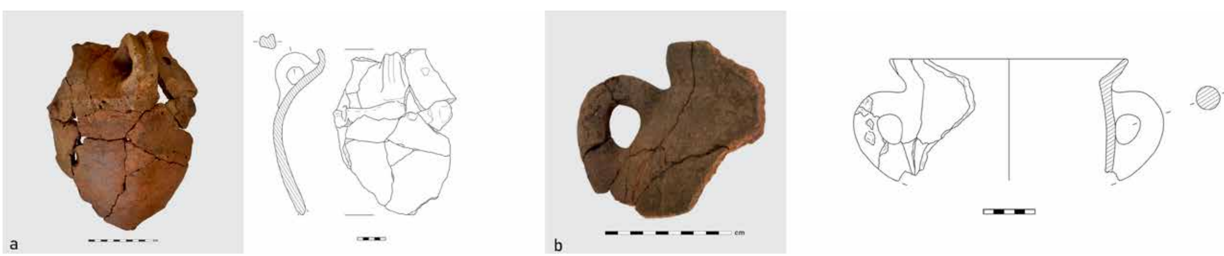

Fig. 21.18 LBA cooking pottery wares from Trimpina. a pyraunos; b wheel-thrown jar (© a PlantCult Project, photos A. Dimoula, drawings D. Chondrou).

the shoulder, which was probably legged (Fig. 21.18b). The pyraunos has an ovoid vessel with outward rim, vertical grooved handle, below which a curved pedestal with circular holes is attached (Fig. 21.18a).

The other two sites, Rema Xydias and Pigi Artemidos, are roughly contemporary (15th-12th c BC). In Rema Xydias, the cooking pots from an apsidal building equipped with a central circular thermal structure were studied, along with its external areas and the adjacent enclosure walls (Koulidou et al 2014). In Pigi Artemidos, architectural features are ambiguous, however we studied the cooking pots found on an open-air stone built structure of unkown use, along with the ones found among various architectural remains (Koulidou 2010, 2012). The cooking pots from both sites can be grouped in three categories (Dimoula et al 2022c). The first is that of large jars with ovoid body, simple flat on top rim, below which vertical strap handles are attached, and narrow flat or curved base (Fig. 21.19a). The second comprises smaller globular jars with thinner walls, outward rims with concave necks, accompanied by vertical strap handles. Some of these vessels preserve traces of the attachment point of legs on the lower part, thus they are interpreted as tripods (Fig. 21.19b). The ones that do not preserve this part could also be interpreted as flat-based jars. Finally, the third category includes pyraunoi, with either ovoid or globular body, pointed or curved base, simple or concave neck and two vertical strap handles, below which the pedestal is attached (Fig. 21.19c).

Regarding the technological characteristics of LBA cooking pots, information is rather scarce. Nonetheless, in all publications cooking fabrics are referred to as coarse-medium grained, and generally porous. Detailed data are available only for Toumba Thessalonikis indicating the use of mostly non-calcareous clays, containing either altered basic or ultrabasic igneous or acid metamorphic rock fragments, all components encountered in geological formations adjacent to the site, though in different locations (Kiriatzi 2000, 173, 189). The results of the petrographic analyses we conducted confirm this appreciation, further indicating that their composition varies according to the geological environment of each site. The Angelochori

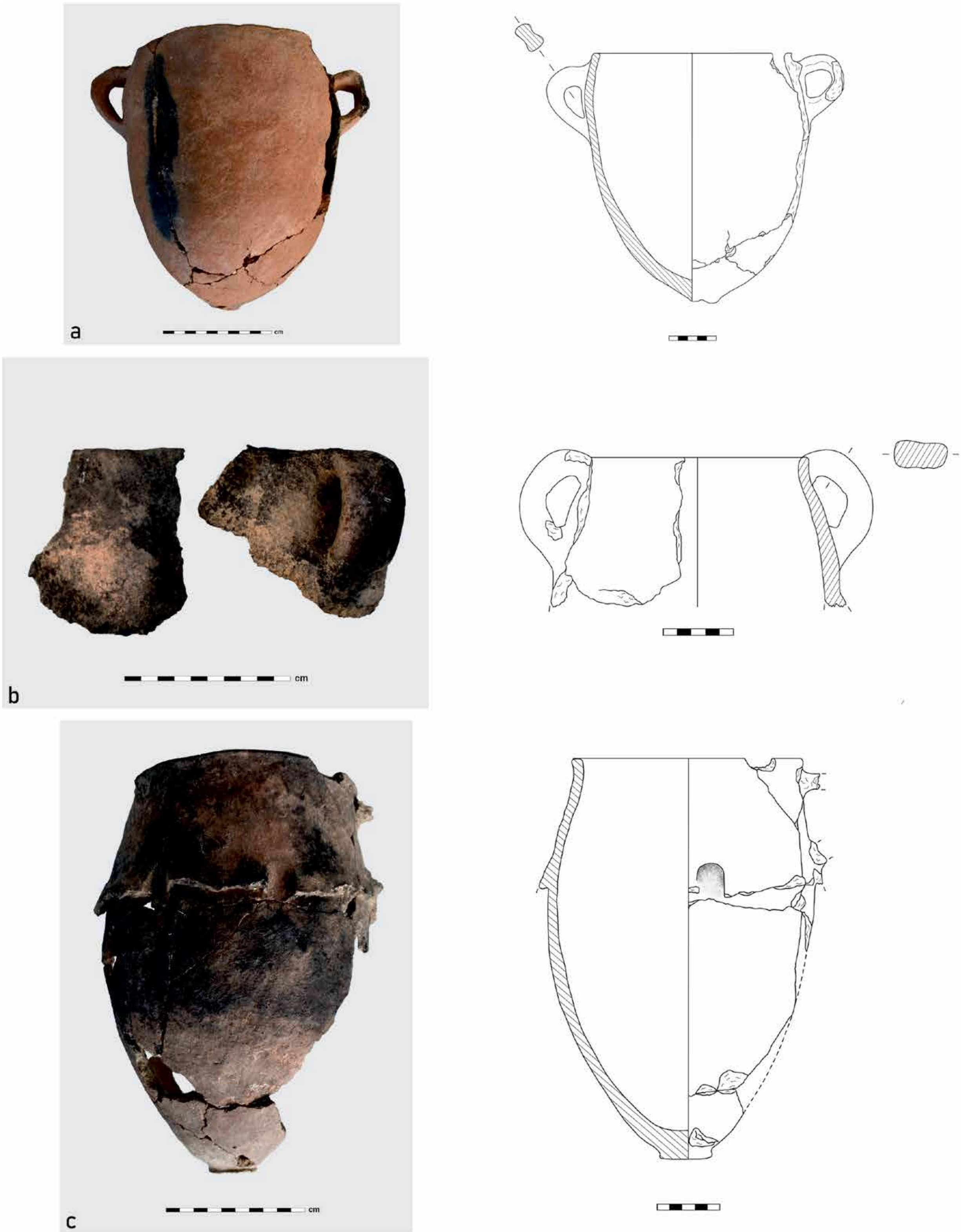

Fig. 21.19 LBA cooking pottery wares from Rema Xydias. a large jar; b tripod jar; c pyraunos (© a PlantCult Project, photos A. Dimoula, drawings D. Chondrou).

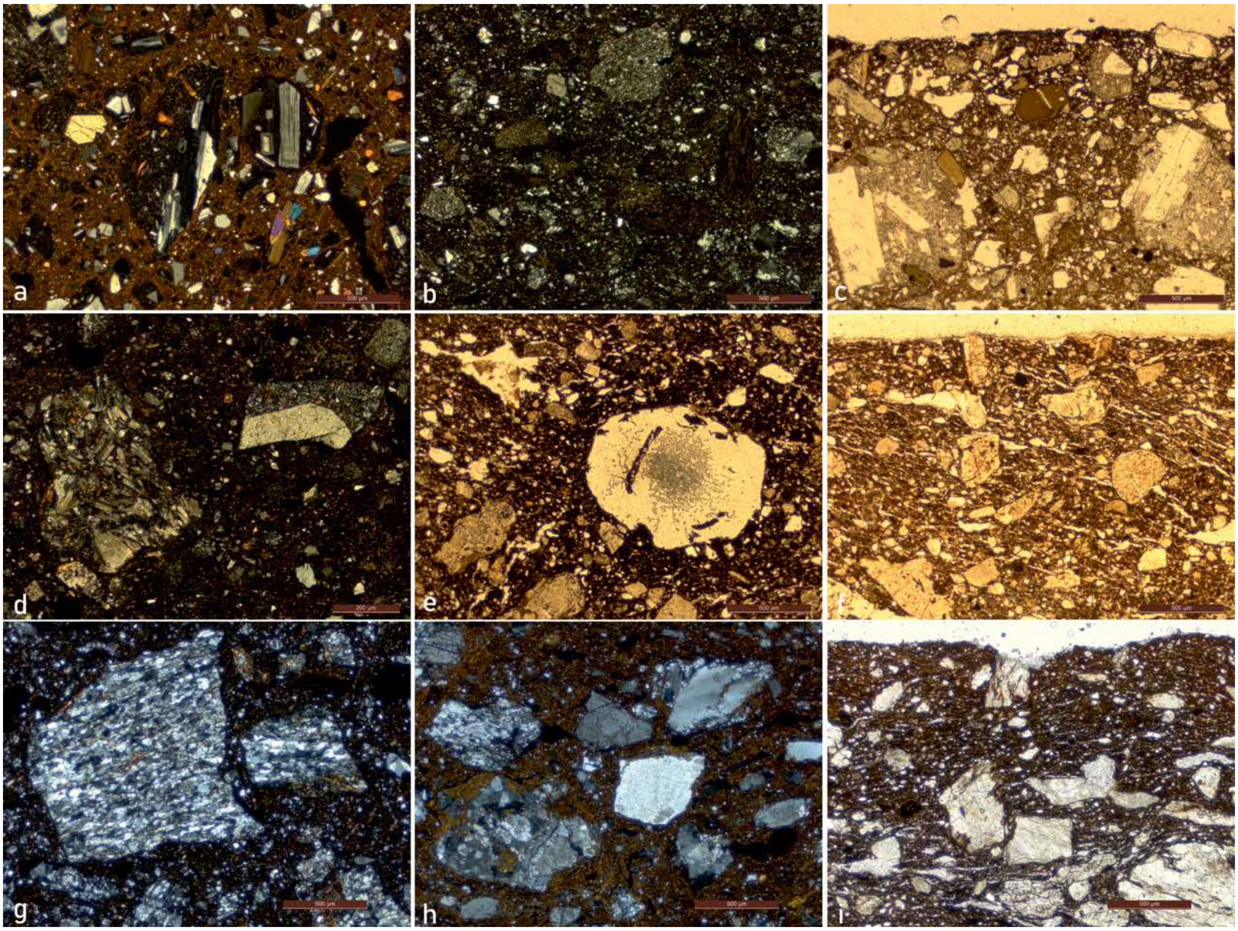

Fig. 21.20 Microphotographs of LBA cooking pottery fabrics in thin section. a coarse, igneous inclusions, from Angelochori (XP); b coarse, metamorphic inclusions, from Angelochori (XP); c absorption of charred material in internal wall, from Angelochori (PPL); d coarse igneous inclusions, from Chokoba 18A (XP); e coarse, plant inclusions, from Chokoba 18A (PPL); f absorption of charred material in internal wall, from Chokoba 18A (PPL); g coarse groundmass, metamorphic inclusions, from Rema Xydias (XP); h fine groundmass, metamorphic inclusions, from Pigi Artemidos (XP); i absorption of charred material in internal wall, from Rema Xydias (PPL) (© PlantCult Project, A. Dimoula).

cooking fabrics are characterised by the use of non-calcareous clays that contain either intermediate igneous (andesite, trachyte) or metamorphic (schist and phyllite) rock fragments, again found in the geological environment of the site but in different locations (Dimoula et al 2022b) (Fig. 21.20a, b). The Chokoba 18A cooking fabrics have non-calcareous clays and contain altered igneous rock fragments (andesite, tuff), the sources of which have been identified in the vicinity of the site (Leshtakov et al 2019, 38) (Fig. 21.20d). Finally, the cooking fabrics from the Pieria sites have a low iron content and contain high grade metamorphic (gneiss, schist, serpentinite) and less igneous rock fragments (Fig. 21.20g, h). These derive from the formations developed in the east piedmont of Mount Olympus in the broader area of the sites, with very few exceptions (Dimoula et al 2022c).

As for the ceramic paste preparation most fabric groups from all sites exhibit a clear distinction between the clay fraction and the mineral inclusions that are commonly angular-subangular in shape, pointing to the practice of clay tempering with crushed rocks or the mixing of two different clay types, a medium grained and a very coarse loose one (Fig. 21.20). Moreover, some fabric groups evidence the practice of organic material addition in the clay paste (Fig. 21.20e). In the Pieria samples the organic component appears to be a natural constituent of a possibly surface clay sediment, while in the Chokoba samples, the presence of organic material is regular, pointing to the deliberate addition of plant stems or seeds in the clay mass, as identified from the shape of their pores. For the first time, different fabrics are used for the production of different shapes. The case was already suggested for Toumba and Agios Mamas

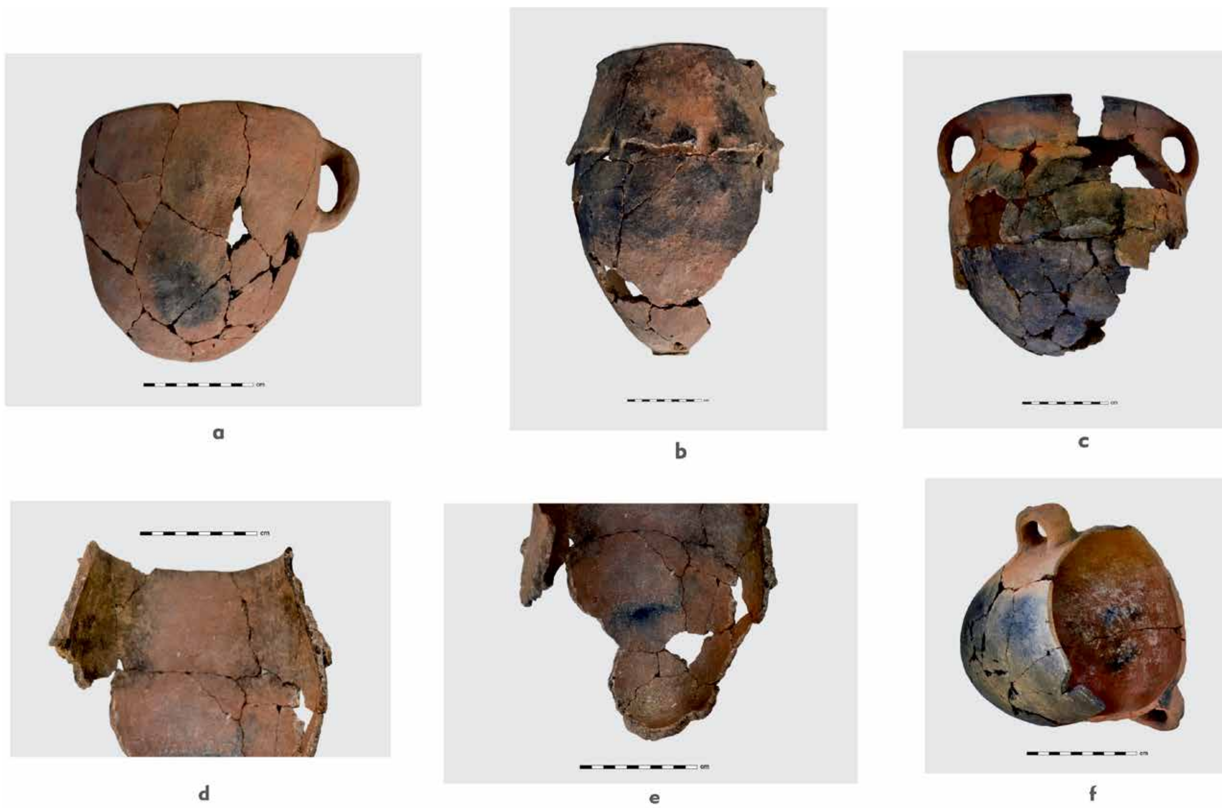

Fig. 21.21 LBA cooking pottery use-wear traces from Rema Xydias. a. large jar; b, c pyraunoi; d internal sooting clouds above liquid level; e abrasion traces on bottom; f attrition traces on internal wall (© PlantCult Project, A. Dimoula).

(Kiriatzi 2000; Horejs 2007, 150), but is now confirmed in Angelochori, where pyraunoi and jars are produced with completely distinct fabrics (Fig. 21.20a, b), as well as in the sites of the Olympus area (Fig. 21.20g, h).

The only building technique attested in all assemblages is coiling, supported by the common orientation of elongated particles in thin section either parallel to vessel walls or random, with coils joined through vertical drawing (see Berg 2008, 1178). In the seldom case of the wheel thrown jar from Trimpina, orientation is diagonal to vessel walls (see Roux and Courty 1998, 753-755). Vessel surfaces are smoothed or coarsely burnished, while the interior appears to be better processed, possibly due to the vessels' use. Vessels appear to be fired in different conditions and temperatures, possibly related to open firing. The majority is estimated to have been fired in low temperatures (<800 ^{o}C for Chokoba and Olympus fabrics) but also higher ones have been observed (>800 ^{o}C for Angelochori and Olympus fabrics).

As for use-wear traces, information on which is generally absent from the relevant literature, our study has shown that large convex based jars from the Pieria sites have mostly oxidized bases, indicating use among fuel, either supported by a pedestal or hung, with the flames licking the vessel walls (Fig. 21.21a). The tripod pots have sooting clouds on the body and upper part, while the lower part is commonly burnt, indicating direct contact with fire (Fig. 21.19b). In the case of pyraunoi, the interior of the pedestal bears dense sooting clouds, as fuel is placed underneath trapping fire and smoke. On the other hand, the bases are commonly oxidized, indicating that they were in contact with the fuel. Sooting clouds are also developed above the pedestal ventilation holes, through which smoke passes (Fig. 21.21b, c). Vessels' interior is commonly clean from traces, with some exceptions. In one jar from Rema Xydias extended attrition traces, in the form of flaking, were recorded (Fig. 21.21f), while in one pyraunos sooting clouds develop above content level (Fig. 21.21d) and there are abrasion traces on the bottom, in the form of scraping, pointing to the use of a pointed stirring tool (Fig. 21.21e). Thin section analysis suggests wet food cooking according to the penetration of charred material in vessel walls (Fig. 21.20c, f, i).

21.9 Discussion

21.9.1 Cooking pots in research and across space

Bibliographical research on prehistoric cooking pots, conducted in the context of the PlantCult project, has provided ample data, characterized though by asymmetries among regions and between periods. This is directly linked to the state and directions of research, but is also related to the quantity of cooking pots included in the assemblages, their degree of preservation, along with the presence or absence of identifiable characteristics to support their use. Targeted studies on use traces, mainly fire clouds and food carbonization, are quite recent and limited, as are also fabric or content analyses. As such, for the early periods of the Neolithic data is quite limited (Table 21.2). For the late Neolithic phases data is more abundant, since extensive areas have been excavated and cooking pots appear to be more numerous and distinct (Table 21.3, 4). Still, LN I data come mostly from the Greek areas (Table 21.3), while LNII/FN (Chalcolithic) data mostly from Bulgaria (Table 21.4). In the early phases of the EBA information derives solely from the eastern areas of Macedonia and Bulgaria, while in the later EBA phases there is a remarkable increase of data across all regions, related to the wealth of domestic contexts (Table 21.5). This image changes abruptly in the MBA in both countries, with information being scant and deriving mostly from coastal sites in northern Greece (Table 21.6). For the following LBA phases, there is sufficient data from the large tells in central and eastern Macedonia, while more limited is the information from Bulgaria (Table 21.7). Finally, as a general comment on the state of pottery research, it should be mentioned that for the Bronze Age periods typological data on cooking pots prevail, while for the Neolithic periods analytical data on fabrics are more common.

All types of prehistoric cooking pots are found in all types of settlements, either tells or flat extended or caves, and all types of contexts (Table 21.2-7). They are found in house interiors, built over or below ground, but also in open-air areas, in yards and streets, as also in outdoor features such as pits or ditches. They are often associated with thermal structures, interior or exterior, but this cannot be set as a rule, as they are also found in the absence of such facilities. In the macro scale a slight shift in contexts can be observed in the course of Prehistory. Neolithic cooking pots are associated with either above ground buildings or pit structures, with thermal structures found in the interior and/or in open-air spaces. In the Bronze Age above ground buildings equipped with thermal structures prevail, but courtyards or pits are still in use.

21.9.2 Cooking pots in types and across time

The cooking pots of all periods and regions under study have certain characteristics in common which are directly related to their function. As such, the majority are deep vessels, to contain sufficient quantity of food. There is also a minority of shallow ones with large diameter, but the intermediate shapes are generally absent. Moreover, their mouth is either wide or open, not closed, apparently related to content monitoring. As for rims they are generally simple or outward, suitable for cooking use, as inward rims would incommode food and tool handling. Their bases are either flat, to stand on a heated surface, or curved, to be supported above fire. The latter is sometimes achieved by manufacture, with attached legs or pedestal below the base. Finally, they commonly feature lugs or handles for their handling over or off fire. Beyond these very general attributes, the results of this study have shown that although cooking pots are characterized by a relative homogeneity across space, they exhibit significant variability across time, two arguments that will be discussed in parallel.

The use of pottery for cooking appears to be infrequent in the second half of the 7th mill BC, while cooking pots are clearly recognized in ceramic assemblages after the transition to the 6th mill BC, when house equipment becomes generally more apparent in the archaeological record (e.g. storage vessels, see Urem-Kotsou 2017) (Table 21.2). Still, the cooking types of these early phases do not comprise distinct categories, but are rather typologically common with other use classes. Thus, if their dimensions are also taken into account, bowls could also be large-sized tableware, jars could be storage or transport vessels and dishes could be large plates. Moreover, they commonly do not feature robust lugs or handles, rather useful accessories in cooking, but small ones, often perforated and pointing to hanging. It is actually their fabric and use-wear traces, in combination with their contexts, that indicates their use. These observations make us deduce that early potters did not manufacture specific ceramic types for cooking pots, but rather produced coarse and/or large sized versions of the available repertoire.

In contrast, entering the Late Neolithic period (LNI) potters appear to develop the above earlier types and produce specific cooking pot types (Table 21.3). Thus, shapes are more standardized, mainly hole-mouthed, probably for sustaining heat, and less open, where food monitoring is easier, with exclusively flat bases, larger-sized lugs and rarely handles. Two types that deserve further discussion are cooking dishes and legged pots. The first develop upon the MN dishes, acquiring larger dimensions and discrete typology. Legged vessels appear to be an innovative type, possibly elaborating the practice of supporting a vessel over fire, and materializing it by attaching legs -elements also met in other ceramic classes- below the already known deep shapes, open or hole-mouthed.

Interestingly, the use of dishes and legged pots appears to cease during the later phases of the Neolithic (LN II-FN), when the hole-mouthed types and, less, the bowls continue to be in use (Table 21.4). This selective rejection and maintenance of cooking pot types is difficult to explain, especially since it is not associated with changes in other cooking equipment classes or food ingredients (see Dimoula et al 2022). Nonetheless, the vessels of this period appear to be even more standardized, with various size formats, small to large. The small collared or the large handled jars of the late 5th-early 4th mill BC could be considered as forerunners of the following EBA shapes, but the nearly a millennium gap between the assemblages of the two periods does not allow for any firm statement.

In the EBA phases, the repertoire of cooking pots is altered, with the initiation and prevalence of the tradition of "pithoid" jars, continuing rather unchanged throughout the MBA and also in the early phases of the LBA in Greek Macedonia, and the entire LBA in Bulgaria. The use of bowls and/or jugs is occasionally documented, but it is not clear if they were intentionally manufactured for cooking or if they were circumstantially used during their lifecycle. On the other hand, the new types introduced during these periods appear to be a result of contacts with other areas, such as the South for cooking dishes and north-eastern European areas for pyraunoi.

It is in the second half of the 2nd mill BC that the preceding "pithoid" cooking pot types are gradually replaced by globular wide-mouthed pots, somehow reminiscent of the "chytrae" of the historical periods. This could be related to contacts of the region of Macedonia with Southern Greece, where such characteristics are common, mostly in wheel-made formats. Perhaps the societies of the region, which were acquainted with southern or Mycenaean pottery types, as evidenced by the presence of imports or local reproductions, imitated or borrowed generic characteristics and incorporated them into the local pottery traditions (Kiriatzi and Andreou 2016).

A characteristic example which demonstrates clearly how complex interaction networks are, and how they develop in parallel towards various directions and in various extents and intensities, is that of the coastal region of Macedonian Olympus. As discussed above, the LBA cooking pot assemblages from sites there include cooking pots related with diverse traditions: local jars, pyraunoi that attest for affiliations with northern areas, but also tripods, a type actually abandoned after the LN I period in the region and found in the Mycenaean sites of south and central Greece. Tripods are generally absent further north, with very limited examples in some coastal sites, while pyraunoi are largely absent further south, with very limited examples in central Greece (Dimoula et al 2022c).

21.9.3 Cooking pots in fabrics

Cooking pottery fabrics across the regions and periods under study share specific technological attributes, directly associated with their intended manufacture, or selection among others, for repeated use over fire. Thus, they are generally coarse grained and moderately porous, have minimal surface treatment and are fired in relatively low temperatures (<850^{o}C). However, our detailed technological study demonstrates that beyond this first level of homogeneity, there is much variability in materials and techniques among regions and periods, related to a degree to the available sources in each site's environment, but predominantly to potters' perceptions and choices.

Accordingly, the 7th-early 6th mill BC fabrics are coarse-medium grained, due to the presence of various mineral inclusions, and relatively porous, as a result of kneading or tempering, but also due to the common presence of organic inclusions, charred during firing and creating voids. Clay processing techniques include both the removal of inclusions, through handpicking and occasionally sieving, but also their addition through tempering. Vessel surfaces are very rarely slipped, which diminishes porosity, and are usually well smoothed or burnished. Most importantly though, the cooking pot fabrics of this period, as the shapes discussed in the previous chapter, are common with other pottery classes, such as tableware (Dimoula et al 2014; Saridaki 2011, 2019). This supports the argument that MN cooking pots were possibly not produced as a separate category, but rather comprised coarse versions of existing types.

In LN I the composition and structure of cooking pot fabrics is quite similar to that of the MN, though with a greater differentiation in fabrics, indicating the application of various recipes. Moreover, in the majority of cases there is no particular relation between vessel fabric and shape/ware, meaning that fabrics used for the manufacture of cooking pots were also used for other pottery classes or the opposite (Tsirtsoni and Yiouni 2002). An exceptional case is that of Makrygialos (Table 21.3) where cooking pot fabrics are characterized by the broad presence of shells, inclusions that are believed to improve the thermal properties of cooking vessels (Tite and Kilikoglou 2002).

The relation of a single clay recipe for the production of cooking pots evolves in the later phases of the Neolithic. Thus, in the case of Dikili Tash, from the three fabrics used in LN I only one continues to be in use in the LN II/Chalcolithic, perhaps chosen as more suitable for cooking pot manufacture over the others, without excluding other factors, such as sources manipulation or simply a matter of taste. In the contemporary sites in north Bulgaria, recipes are also homogeneous. In this period the practice of burnishing also ceases, with smoothing being the predominant surface treatment technique.

For the EBA the results of our study suggest that limited fabrics are related with cooking pottery production. In Archondiko the majority comprises natural coarse sediments and less processed raw materials, as is the case in Sokol. However, the texture of all fabrics points to rather rough processing of materials, i.e. use of surface clays with organic and calcific material. The impression acquired is that the fabrics create or follow the "crude" appearance of the pots of this period, in comparison to the previous neatly made -from a present viewpoint- Neolithic pots. Of course, these pots are perfectly functional over fire, which possibly means that potters or people emphasized this aspect over aesthetic ones. Moreover, it is during this period that fabrics develop to be more "specialized", meaning that they are not associated with all pottery classes, but the spectrum is limited to specific use categories. As such, the fabrics used for the production of cooking pots are also used for storage vessels or coarse tableware, possibly also used in cooking, but not for other uses, such as transport or liquid storage (Dimoula et al 2022b).

For the following MBA phase, our analysis suggested the use of a single fabric for the production of different types of cooking pots. During the LBA cooking pot fabrics are again limited, but their processing appears to be elaborate, with tempering or clay mixing being the predominant practices. Furthermore, the innovation of this period, not observed in any of the previous ones, is the relation of specific fabrics with specific cooking pot types. Thus, pyraunoi and jars are commonly linked to separate clay recipes, which possibly indicates a further specialization in the relationship between fabric and use.

21.9.4 Cooking pots in use

The use-wear traces identified on the prehistoric cooking pots under study share common patterns among regions and periods, as is the case for their types and fabrics. Starting with exterior fire traces, either soot or decolorization, which attest for the placement of the vessel over fire (Skibo 2013), the results of our analysis suggest three modes.

The first is placing the base of the vessel among fuel and/or fire, either on a hearth floor or over ground. This mode can be associated with flat-based vessels, comprising the vast majority of the material, or with curved-based ones, possibly supported by some means, such as stones evidenced in MN Lete I (Fig. 21.4b), or sunk in coals, that could be the case for curved-based cooking dishes, as the ones from LN I Dikili Tash (Fig. 21.5d).

The second is raising the vessel above fuel/fire, which is achieved by various means. These include hanging, as is possible in MN Lete I (Fig. 21.2b), using supports of different material (stone, clay or metal), as is possible in LBA Rema Xydias (Fig. 21.19a), or using thermal structures with high walls and opening on top, where the vessel is placed, such as in EBA Archondiko (Fig. 21.13a). These ways would be expected to be related mostly with curved-based vessels, but our study has shown that flat-based ones are also commonly used in a raised position. The latter is also achieved by vessel manufacture with the attachment of legs or pedestal, as is the case for the LN I Dikili Tash (Fig. 21.5c) and LBA Rema Xydias (Fig. 21.19b) tripods or the pyraunoi from LBA Angelochori and Chokoba 18A (Fig. 21.16a, 17). In these cases, the bases are again either flat or curved, while they can also be placed among piled fuel, if the first cooking mode is to be conducted.

Finally, the third mode is the placement of the vessel next to fuel and fire, which is indicated by traces but quite difficult to ascertain, as most vessels do not appear to have been related to a single cooking mode, but were rather versatile.

Nonetheless, the types of bases, i.e. flat vs curved, but predominantly the position of the vessel in relation to fuel and fire, i.e. among or above them, can be tentatively associated with different cooking methods, namely with steady temperature slow cooking vs high temperature quick boiling, according to a recent series of pilot cooking experiments (see Dimoula et al 2020). The collected evidence suggests that the three cooking modes, and thus different cooking methods, basically coexist in the regions and periods under study. At this point, it is interesting to comment that the majority of prehistoric cooking vessels feature lugs in various shapes and sizes, mostly unperforated, which can be related with vessel lugging over a flat surface. On the other hand, handles, which can be linked to lifting, are present, but not frequent; they actually become a norm in the Late Bronze Age phases, when curved bases are also generalized, possibly to meet the need of lifting such vessels over fire.

Moving to the interior traces, which are mostly related to temperature and contents, the results of our study indicate various patterns. As such, many of the vessels have their interior clean from traces, which suggests high liquid presence and vessel wall temperature not exceeding 300 ^{o}C. On the other hand, respectively many vessels are characterized by internal carbonization, located mainly on the base and lower walls and less on the upper part (Fig. 21.4a), related to vessel wall temperature exceeding 300^{o}C, but also the practice of dry cooking or limited presence of liquid. We believe that the latter is the case for the majority of the vessels under study, since they exhibit penetration of charred material in their wall, documented clearly by dark interior margins in thin section, directly linked to continued simmering of thick food (Skibo 2013). This general image accounts for all regions and periods under study, and is in accordance with the generalized use of deep vessels, pointing to the broad practice of wet cooking with either maintenance of liquid, such as soups or stews, or its deliberate evaporation, such as porridges or mushes. Only for the shallow cooking dishes baking use, for either pies or bread, can be supported, without excluding the wet cooking use, especially for the curved-based ones.

A final point of interest concerns the sizes and capacities of prehistoric cooking pots in our study area (Table 21.2-7). In the early phases of the Neolithic the majority are medium-sized (2-5 l), in LN I medium and large sizes prevail (2-10 l), while in the later phases of the Neolithic/Chalcolithic medium and large sizes (1.5-9 l) are also accompanied by small sized pots (<1 l). Throughout the Bronze Age periods sizes are varied, from small to very large (0.5-10, up to 50 l). Thus, from the later Neolithic phases and throughout the Bronze Age different in size vessels participated in cooking, indicating perhaps different scales of food preparation, e.g. personal to communal, or even a more sophisticated cuisine, e.g. preparation of different dishes in small or large-sized vessels.

21.10 Conclusions

This diachronic overview of prehistoric cooking pottery in northern Greece and Bulgaria, drawing data from both bibliographical research and analysis of original archaeological material, sheds light to many aspects of its production and use, setting the agenda for future research. In terms of archaeological practice, our study showed that the positive identification of cooking pottery requires a series of parameters: secure contexts to support cooking activity, well preserved vessels to have a complete image of the morphological details (e.g. combination of base and handle types) and the use-wear traces developed along the surfaces, along with analytical data on fabric, to restore technological choices and use effects. This study demonstrated that the combination of the above observations does not only establish cooking use but provides further refined information on the rather complex relation between pottery fabrics, shapes and wares, intended functions and actual uses of vessels, together with their association with heat sources and contents.

As such, the results of this study suggest that although prehistoric people utilized fabrics and shapes/wares whose attributes responded to a use over fire, these were not necessarily restricted to cooking but were possibly shared with other use categories, such as storage or tableware. These versatile vessels were in use throughout the periods and regions under study, while they were accompanied by especially designed cooking vessels, such as the supported or the shallow ones, only in specific -and interestingly not consecutive- periods. Moreover, it becomes apparent that it is potting traditions and choices, together with available resources, that designate cooking pottery technology and production, with use having a secondary role.

Thus, as stated in the beginning, the evolution of cooking pottery is by no means linear, from simple to complex forms and technologies, but rather a tangly scheme involving use transformations and adaptations, preservation of traditions and innovations, rejections and revivals. The most diverse cooking sets in terms of sophisticated shapes develop in the Late Neolithic and the Late Bronze Age; in terms of sizes and capacities in the Late-Final Neolithic/Chalcolithic and throughout the Bronze Age; in terms of specialized fabrics in the Bronze Age. Finally, elaborate cooking sets do not necessary rime with complex architecture, neither the opposite, but are possibly related to the dynamics of social groups in every period. Our study aspires to pave the way for further research, analyses and experiments, on the parameters that affect the relationship of prehistoric societies with food and cooking.

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Chapter 22

Plant boiling among the first pottery-making societies in the southern Levant: an insight from charred residues of pottery

Julien Vieugué, Monica Ramsey, Yosef Garfinkel

Abstract

It is now known that the first pottery-making societies in the Levant used pottery to cook their food. Nevertheless, many questions remain unanswered about the cuisine of these Neolithic communities who lived during the late 7th/early 6th mill cal BC: what type(s) of food preparations were cooked in the ceramic vessels? Which cooking technique(s) were used at that time? To answer these questions, we undertook a thorough analysis of 153 fragments we identified as cooking pots from the key Early Pottery Neolithic (EPN) sites of Sha'ar Hagolan and Muntaha located in the Jordan Valley. The multidisciplinary study method, developed at the interface of traceology and botany, is based on the combined macro- and microscopic characterization of outer soot deposits and inner charred residues of Neolithic pots. The distribution and visual aspect of the various carbonized traces found on the surface of the ceramic vessels suggest that the 153 pots examined were only used to boil foodstuffs by being placed in the center of stone hearths. Furthermore, the analysis of phytoliths and starch trapped in the inner charred residues of five of these vessels revealed that they had contained various food preparations based on cereals (namely wheat and barley) and potentially wild grasses and fruits (including acorns). Although carried out on a limited number of cooking pots, this exploratory study sheds new light on the ways in which domestic and wild plants were processed during the late 7th/early 6th mill cal BC. It underlines the importance of cereal porridges in the diet of the first pottery-making societies in the Levant.

Keywords: *residues, food, diet, pottery, Early Pottery Neolithic, Near East, Southwest Asia*

22.1 Introduction

Was the earliest pottery of the Near East used to cook food? This question, which is crucial to understand the causes for the widespread adoption of ceramic technology in the Fertile Crescent, has long been debated by researchers (see Barnett and Hoopes 1995; Rice 2000; Tsuneki et al 2017 for a synthesis of the different hypotheses). In the 1990s, several petrographers attempted to elucidate the issue through the analysis of the physical properties of pottery fabrics. Often made from highly calcareous clays that are known for their low thermal and mechanical shock-resistance, the pottery made

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during the 7th mill cal BC proved to be poorly suitable for food cooking (see Le Mière and Picon 1994, 1998, 2003 for the Northern Levant; Goren et al 1993; Goren and Gopher 1995; Gopher 1998 for the Southern Levant). Nevertheless, the presence of vessels highly tempered with coarse mineral inclusions (basalt or crushed calcite type) from the beginning of the 7th mill cal BC suggested that some of the shaped pottery was intended to be used on fire (Le Mière and Picon 1994, 2003). This hypothesis was supported by the observation of carbonized traces on the surface of some of the earliest ceramic vessels in the region (Moore 1995; Le Mière and Nieuwenhuyse 1996; Verhoeven 1999). In the 2000s, several chemists questioned the use of the first Levantine pottery for cooking based on the analysis of organic residues. Given the scarcity of lipids preserved in the porous walls of these ceramic vessels, it was concluded that most of pottery made during the 7th mill cal BC was not used for food cooking (see Gregg 2009 for the Northern and Southern Levant). Nevertheless, the high concentration of lipids and the presence of ketones detected in a number of pots from this pivotal period revealed that some of them had unquestionably been used on fire (Evershed et al 2008; Nieuwenhuyse et al 2015). According to the chemical signatures, these ceramic vessels would have been used for cooking subcutaneous animal fat from ruminants and non-ruminants as well as dairy products (Copley et al 2005; Evershed et al 2008; Gregg et al 2009; Thissen et al 2010; Gregg and Slater 2010; Nieuwenhuyse et al 2015). The hypothesis of early pottery used for food cooking was reinforced by the identification of outer soot deposits and inner charred residues on other ceramic vessels undoubtedly dated in the 7th mill cal BC (Nieuwenhuyse et al 2010; Myiake 2017).

Although numerous lines of evidence now indicate that some vessel types dated in the Early Neolithic period in the Near East were used to cook food, many grey areas remain. What type(s) of food preparations were cooked in the ceramic vessels? In particular, which plant substances were prepared in the pots? What cooking technique(s) were used? Were the ingredients boiled, roasted, grilled or fried? To answer these questions, we undertook a thorough analysis of cooking pots from several EPN sites in the Southern Levant – a region located at the crossroads of Africa and Asia that has so far remained on the fringes of research carried out on the Early pottery in the Fertile Crescent (see Tsuneki et al 2017). The multidisciplinary protocol, developed at the interface of traceology and botany, is based on the combined macro- and microscopic characterization of outer soot deposits and inner charred residues of ceramic vessels. This innovative approach has shed new light on the cuisine of the first pottery-making societies in this part of the Fertile Crescent.

22.2 The first pottery-making societies in the southern Levant (6400-5700 cal BC)

The late 7th/early 6th mill cal BC represents a turning point in the long process of the Neolithic transition in the Near East (Marciniak 2019). This period is characterized by the irrevocable shift of Levantine societies towards an economic system based on the mixed husbandry of caprine (goats and sheep) and bovine (cattle) as well as on the hybrid cultivation of domestic cereals (wheat, barley) and legumes (peas, lentils) (Twiss 2007). It was also the period when pottery became widespread throughout the Fertile Crescent, adding to the range of mineral (stone and plaster) and organic (wood and basketry) containers previously made and used by prehistoric groups (Nieuwhenhuyse 2007).

22.2.1 The Early Pottery Neolithic and the Yarmukian culture

Compared to the other regions of the Fertile Crescent, the Southern Levant shows a certain delay in the appearance of pottery. The EPN there begins around 6400 cal BC (Gopher 2012), at least 600 years after Mesopotamia (Campbell 2017). Several pottery-making societies emerged during the following centuries (Gopher 2012), of which the Yarmukian is certainly the most emblematic (Garfinkel 1993; Kafafi 1993; Gopher 1998). This entity, by far the best defined, emerged following the cultural (Rollefson 1993) or demic (Amiran 1969) diffusion of pottery technology, which was adopted to meet a new economic (Eirikh-Rose and Garfinkel 2002), social or even symbolic need (Goren et al 1993; Goren and Gopher 1995). The Yarmukian culture flourished during the last quarter of the 7th mill and the first quarter of the 6th mill cal BC (Gopher 2012), during which time the production and use of pottery gradually became more widespread (Gopher and Eyal 2012; Eirikh-Rose 2019). It then declined. The EPN ends around 5700 cal BC (Gopher 2012).

In the current state of research, fifteen Yarmukian sites are known, a third of which have been the subject of large-scale rescue or scheduled excavations (Fig. 22.1). The Yarmukian sites are spread over a limited area of 10,000 km^2, from the Sea of Galilee in the north to the Dead Sea in the south and from the Mediterranean Sea in the west to the Jordanian reliefs in the east (Gopher 2012). These are mostly open-air settlements, composed of circular single-cell houses or rectangular multi-cell buildings organized around internal courtyards (see Perrot 1964, 1965; Rollefson et al 1992; Kafafi 2001; Garfinkel and Ben-Shlomo 2009). The subsistence economy of the Yarmukian populations was based on the husbandry of caprine (goats and sheep) and the cultivation of domestic cereals (barley and wheat) (Wasse 2002; Allen 2002; Marom and Bar-Oz 2013; Davis 2012; Kislev and Hartmann 2012). Other food resources were, however, exploited during the EPN, including a

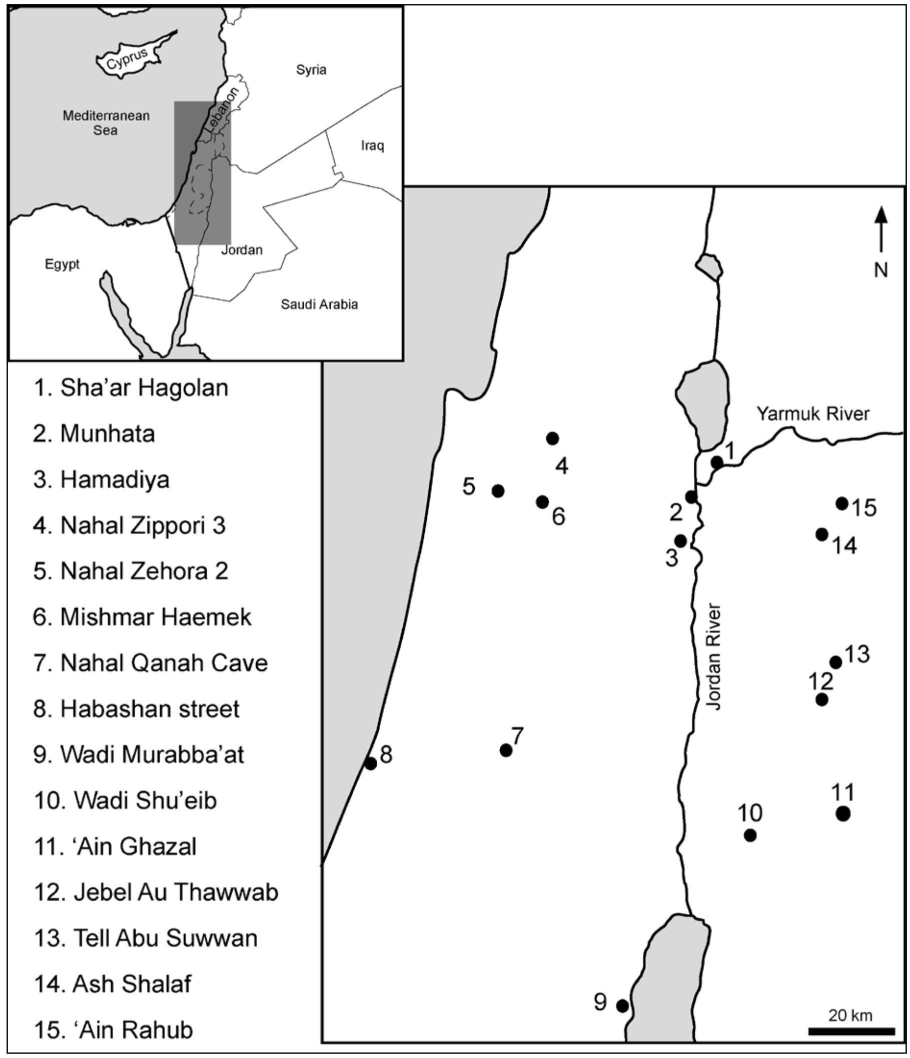

Fig. 22.1 Location of the main Yarmukian sites in the Southern Levant.

variety of wild animals (gazelles, wild boar) and plants (figs, apples, pistachios) (Wasse 2002; Allen 2002; Marom and Bar-Oz 2013; Davis 2012; Kislev and Hartmann 2012). Seeking to shed light on the daily diet of these communities, our investigation focused on the two most extensively excavated Yarmukian sites – namely Sha'ar Hagolan and Munhata that were respectively investigated under the supervision of Yosef Garfinkel and Jean Perrot (Garfinkel and Miller 2002; Garfinkel and Ben-Shlomo 2009; Perrot 1964, 1965). They yielded the two most consistent and best-preserved EPN ceramic assemblages so far discovered in the Southern Levant (Garfinkel 1992, 2019).

22.2.2 The Yarmukian pottery assemblages

To reconstruct the dietary habits of the first pottery-making societies in the Southern Levant, the ceramic assemblages of the major EPN sites of Sha'ar Hagolan and Munhata were subjected to a detailed functional analysis. The combined study of typometry (shape, size, capacity) and use-wear (residues and attritions) of the pottery uncovered at these two open-air settlements has shown that the pottery range is similar to a kitchenware (Vieugué et al 2016) (Fig. 22.2). The assemblages are made up of:

- Long-term storage vessels (26.5%) characterized by high and slightly closed shapes having a very large capacity (from 40 to 100 l).
- Liquid transport and storage vessels (16.5%), characterized by high and very closed shapes of which the volume is medium (from 3 to 16 l).
- Cooking pots (9.5%) identified by the presence of outer soot deposits and/or inner charred residues. The residues are generally preserved in the form of visible carbonized matters trapped in the porous walls of the pots, sometimes associated with tiny crusts.
- Pots used for service and consumption (35.5%) characterized by low and open shapes having a small capacity (between 0.5 and 2 l).

Carbonized traces have been identified on nearly 10% of the pottery discovered at Sha'ar Hagolan and Munhata. Accordingly, cooking pots appear relatively well represented within the two Yarmukian assemblages studied. The vessels in question are characterized by globular shapes with relatively closed orifice. They are often equipped with two lugs arranged around the outer rim. Their base is mainly round or flattened. The walls of the cooking pots are relatively thick (between 8-17 mm). With few exceptions, they are mainly clay coated and undecorated. The characteristics of the identified cooking pots distinguish them quite clearly from the other functional classes of ceramic vessels used by the Yarmukian populations (Vieugué et al 2016).

22.3 Multi-scalar analytical procedure of cooking pots

In this study, we have set up a new multi-proxy and multi-scalar protocol for the analysis of cooking pots to enrich our knowledge about the cuisine of the first pottery-making societies in the Southern Levant. This analytical procedure, suitable to highly fragmented archaeological remains, is based on the combined study of outer soot deposits and inner charred residues of pottery at macro- and microscopic scales. Because our research was undertaken a long time after the excavation of the sites and the post-excavation treatment of the artefacts (systematic washing of the potsherds; restoration of some of the ceramic vessels), the methodology had to be adjusted to overcome the inherent limitations of the pottery assemblages selected for analysis.

22.3.1 Macroscopic characterization of outer soot deposits and inner charred residues of pottery

To reconstruct the way(s) in which the foodstuffs were cooked in the Neolithic pots, the study first consisted in the macroscopic characterization of the carbonized traces found on the surfaces of the Yarmukian pottery. Such traces include outer soot deposits (which is caused by the burning of wood used as fuel) as well as inner charred residues (linked to the carbonisation of the natural substances processed in the ceramic vessels) (Skibo, 1992). This macroscopic examination of the cooking pots was carried out by Julien Vieugué at the Institute of Archaeology of the Hebrew University of Jerusalem where the pottery assemblage from Sha'ar Hagolan was stored and, at the National treasures department of the Israel Antiquities Authority (Beth Shemesh) where the remains from Munhata were stored. The 153 sherds from both sites with outer soot deposits and/or inner charred residues were meticulously observed with the naked eye (1x) and with a binocular microscope (2x to 10x). Such a low-magnification use-wear analysis, which remains rare in prehistoric pottery studies, was able to document accurately the visual aspects of the carbonized traces visible on the surface of cooking pots (Table 22.1).

With regard to the outer soot deposits, three main descriptive criteria were defined:

1. Location in profile. Given the fragmentation of the archaeological remains studied, we were content to say whether the carbonized traces were found on rim, body or base sherd.
2. Extent. The soot deposits appeared to be localized (less than 25% of the preserved surface of the sherd), partial (between 25 and 75%) or covering (more than 75%).
3. Color. Black, brown or grey soot deposits were distinguished.

With regard to the inner charred residues, six main descriptive criteria were established:

1. Location in profile of the visible carbonized matter having permeated into the porous walls of the ceramic vessels. Same variables as soot deposits.
2. Extent. Same variables as soot deposits.
3. Color. Same variables as soot deposits.
4. Surface regularity of the tiny crusts adhering to the inner surface of the ceramic vessels. These appeared to be either regular or irregular.
5. Adhesion. It was described as weak when micro-fragments of charred crusts detached from the inner surface of the ceramic vessels at the slightest contact

Use-wear type	Criteria	Variables
Outer soot deposits	**Location on the ceramic profile**	Rim/body/base
	Extent	Limited/partial/covering
	Color	Brown/Grey/Black
Inner charred residues	**Location on the ceramic profile**	Rim/body/base
	Extent	Limited/partial/covering
	Color	Brown/grey/black
	Surface regularity	Regular vs irregular
	Adhesion	Weak/strong
	Gloss	Mat/glossy

Table 22.1 Criteria recorded for the outer soot deposits and inner charred residues of pottery from Sha'ar Hagolan and Munhata.

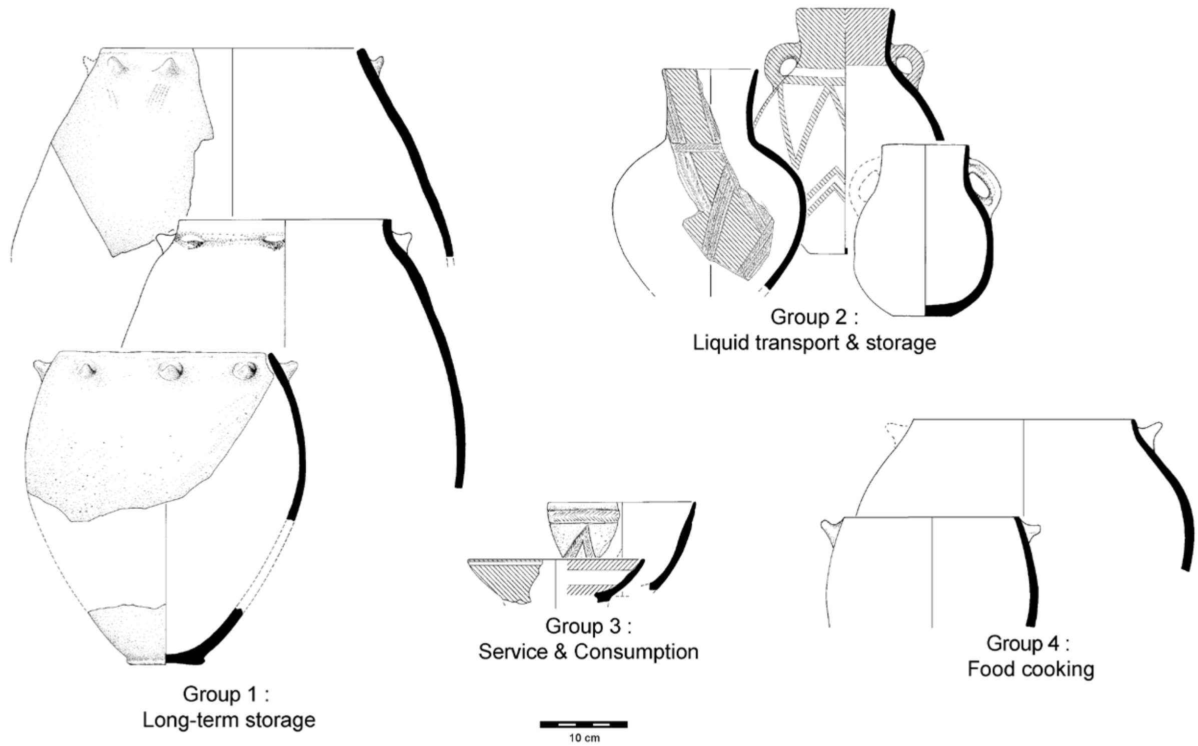

Fig. 22.2 Pottery range used by the Yarmukian communities in the late 7th mill cal BC.

with the sterile scalpel blade; it was considered strong if the opposite occurred.

6. Gloss. The crusts appeared either matte or glossy depending on their reflection in natural light.

The macroscopic characteristics of the charred residues and soot deposits found on the surface of the archaeological cooking pots were interpreted by comparison with those of experimental (e.g. Dimoula et al 2020; Chantran and Cagnato 2021) and ethnographic cooking vessels (e.g. Skibo 1992, 2012; Mayor and Vieugué 2017). This comparative approach has allowed precise assumptions to be made about the cooking techniques that were practiced during the EPN in the Southern Levant.

22.3.2 Microscopic characterization of inner carbonized residues of pottery

To establish the range of plant substances cooked in the ceramic vessels, the study focused then on the characterization of micro-botanical remains potentially trapped in the inner carbonized residues of pottery. The term *plant micro-remains* is here applied to phytoliths (plant opal silica bodies that retain the shape of the cells located in different parts of the plant), starch (common name for carbohydrates composed of two organic polymers), pollen grains and spores (sexual and asexual reproductive units of plants), as well as diatoms (single-celled algae that grow under water). This exploratory research on micro-botanical remains was undertaken by Monica Ramsey at the Dorothy Garrod and Pitt-Rivers Laboratories of the McDonald Institute for Archaeological Research at the University of Cambridge (UK). The tests were conducted on the 5 pottery sherds from Sha'ar Hagolan that present the best preserved visible charred residues (Table 22.2). The preliminary analysis was designed to provide quick proof-of-concept results for a larger study that is currently ongoing. In order to minimize potential contamination during this pilot study, all of the equipment used for sampling charred residues and extracting micro-botanical remains (including centrifuge tubes and toothbrushes) was new and sterile. A stepwise analytical procedure was set up given the scarcity of the pottery residue studies that took into account both phytoliths and starch (see step 2). The protocol can be summarized in four main stages (see Appendix 1 for details):

1. Cleaning of the sherds: The 5 sherds were first carefully cleaned with distilled water to remove surface sediment and possible contamination caused by the cleaning of pottery collections prior to our study.
2. Sampling the sherds: From each of the selected potsherds, three samples were taken as follows. A. charred crusts adhering to the inner surface of

Vessel-Sherd No	Excavation season	Chronological periods	Stratum	Area	Square	Structure no	Structure general description
SHA_CS2158.1	2002	Early Yarmukian	G-11	G	P48a	G167	Stones in compact soil with patches or lenses of softer clay sediment
SHA_CS2206.1	2002	Early Yarmukian/ Yarmukian	G-9/G-10	G	P48a	G174	A rounded pit
SHA_CS3979.1	1999	Yarmukian	G-8	G	P48a	G27	Fill and debris north of wall G20 and floor G16
SHA_CS138.1	2000	Yarmukian	E-4	E	J44c	E491	Debris above floor E490 in northern courtyard A of building complex II
SHA_CS3093.1	2004	Yarmukian	N-2/N-3	N	B3	N97	Debris around burials N119 and N122

Table 22.2 Archaeological contexts of the five cooking pots from Sha'ar Hagolan that were the subject of phytoliths and starch residue analysis.

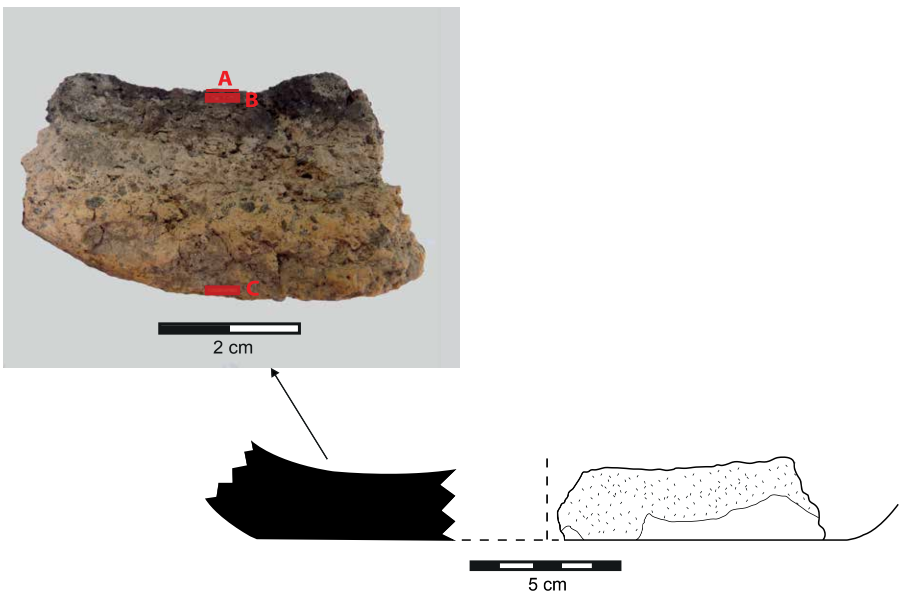

Fig. 22.3 Sampling strategy of the potsherds with carbonized residues. a charred crusts adhering to the inner surface of the cooking pots; b interior sherd fabric with carbonized matters; c exterior sherd fabric with no visible charred residue.

the cooking pots; B. interior sherd fabric (10 mgs) where the carbonized substances have undoubtedly permeated the porous wall of the ceramic vessels and C. exterior sherd fabric (10 mgs) where no charred residue was visible (Fig. 22.3).

3. Pre-treatment and dispersion: This step was only necessary for sherd fabric (samples B and C). The samples were treated with a weak acid and then rinsed. They were then dispersed with Calgon and rinsed (see Appendix 1 for details).
4. SPT Flotation for Starch Grain and Phytolith Recovery and Mounting: The starch and phytoliths were extracted together with one heavy density liquid separation step. The samples were mounted and scanned in their entirety at 20x using a ZeissVision and Zen advanced imaging software (see Appendix 1 for details).

All the micro-botanical remains were identified based on their shape and their size using Ramsey's comparative collections:

- The Mt. Scopus Collection, which focuses on economically important wild plant taxa from Israel and features 148 specimens (Comparative collection stored at the Institute of Archaeology – Hebrew University of Jerusalem).
- The Hillman Collection, which is a Near East grass husk collection that includes 46 wild and domestic grass specimens, mounted from plant samples collected originally by Prof. Gordon Hillman and Dr. Mark Nesbitt (Comparative collection stored at the Institute of Archaeology – University College London).

Starch identifications for these analyses were limited to grouping of like with like, or "types". This conservative approach reflects the state of the assemblage, and the limited number of starch grains recovered. Starch grains are often identified based on the characteristics in populations of "types". However, in this study most of the starch types were only represented by no more than five examples, all found in isolation. Finding starch grains together is particularly important when trying to make finer identifications of the simple round forms with central hilums. For example, AHT starch (*Aegilops, Hordeum and Triticum*) is largely composed of these starch forms, however, they have bimodal Ab pairings (Piperno et al 2004), which are crucial to confidently narrow the identification. Without these pairings, simple round forms between 10-20 microns are found in many of the economically important plant food resources in the region (e.g. Cyperaceae, *Typha*, and a range of wild cereals and grasses).

Insofar as the quantitative analysis of the micro-botanical remains is still on going, the results are presented as presence/absence in this paper. However, the categories of x (n=1), xx (n=2-5), and xxx (n=more than 5) were employed to provide some basic control on the counts.

22.4 Results: Yarmukian vessels used for boiling foodstuffs

The analytical procedure applied to the 153 fragments identified as cooking pots from Sha'ar Hagolan and Munhata has not only allowed us to reconstruct the mode of use of the vessels and furthermore the cooking techniques used by the Yarmukian populations. It has also made it possible to identify the original content of the ancient pots which reflects the nature of the food preparations consumed by these Levantine communities in the late 7th mill/early 6th mill cal BC.

22.4.1 Boiling food using ceramic pots placed in the centre of fireplaces

Were the ingredients boiled, fried or roasted in Yarmukian pots? This question remained open due to the lack of detailed use-wear analyses of the cooking pots that were identified in previous investigations (Garfinkel 1992; Eirikh-Rose and Garfinkel 2002). The charred residues found on the inner surface of the pottery from Sha'ar Hagolan and Munhata are in the form of black impregnations trapped in the porous walls of the ceramic vessels (Fig. 22.4; Table 22.3a). Such impregnations are sometimes associated with tenuous remains of matte black surface crusts that appear very often friable and irregular. The visual aspect of the carbonized impregnations and crusts found in these ancient ceramic vessels is unmistakably similar to the charred residues of present-day vessels used for boiling foodstuffs (Skibo 1992, 2012; Mayor and Vieugué 2017). The ceramic vessels from Sha'ar Hagolan and Munhata which show carbonized traces are, furthermore, all globular in shape with a slightly closed orifice (see Fig. 22.2). The general shape of the pottery, which was undoubtedly used on the fire, is similar to those of the modern ceramic vessels used for boiling foodstuffs (Skibo 1992; De Ceuninck 1994). We therefore have a set of converging clues which allow us to demonstrate that the food prepared in Yarmukian pottery was cooked using the boiling technique (cooking in liquid).

The use of pottery for boiling food leads to a second question: did the cooking pots operate with heated stones or installations such as ovens or hearths? The soot deposits observed on the outer surface of the ceramic vessels from Sha'ar Hagolan and Munhata are in the form of a thin brown-black layer (Fig. 22.4; Table 22.3b). The presence of such carbon depositions immediately rules out the hypothesis of food cooking during which the pottery was never in direct contact with fire, such as those carried out with heated stones. On the contrary, it argues in favor of cooking during which the ceramic vessels would have been in direct contact with the flames, as is the case with open hearths. Based on the limited published field data on the features of the two open-air settlements, it seems that most of the cooking installations found at Sha'ar Hagolan and Munhata correspond to open hearths of 40-80 cm diameter made of stones and ashes (Garfinkel and Ben-Shlomo 2009; Perrot 1964, 1965). No domed oven was found there (Anna Eirikh-Rose, and Julie Bessenay, pers. comm.). This fact supports the interpretation previously put forward of boiled cooking carried out on open fireplaces.

The hypothesis that Yarmukian cooking pots were used on open fireplaces raises a third question: were the ceramic vessels placed in the center or in the periphery of the hearths? The inner charred residues are clearly concentrated at the bottom of the Yarmukian pottery (Fig. 22.5a). This distribution shows that the lower part of the vessels was the area where the heating temperature was the highest. It shows that the ceramics were probably placed in the center of the hearths.

This conclusion leads to a fourth question: Were the Yarmukian cooking pots placed or hung above the hearths? In contrast to the inner charred residues, outer soot deposits are mostly found on the rim and body fragments of the cooking pots. They are rarer on the base sherds (Fig. 22.5b). Such a distribution tends to rule out the hypothesis of ceramics hung above the hearths, which would have led to the preferential formation of soot on the base of the cooking pots. On the contrary, it supports the hypothesis of ceramic vessels placed in the hearths where, in contact with the glowing embers, they are not altered by soot on their outer bases.

22.4.2 Food preparations based on domestic cereals and wild plants

Micro-botanical remains were identified in the 5 cooking pots from Sha'ar Hagolan analyzed. Micro-botanical remains are, with one exception, absent from clay matrix (C samples). Four of them yielded both phytoliths and starch, sometimes in large quantities (i.e. more than 5) (Table 22.4). Our preliminary study shows therefore that these two types of micro-botanical remains are relatively well preserved in the analyzed samples and warrant further investigations.

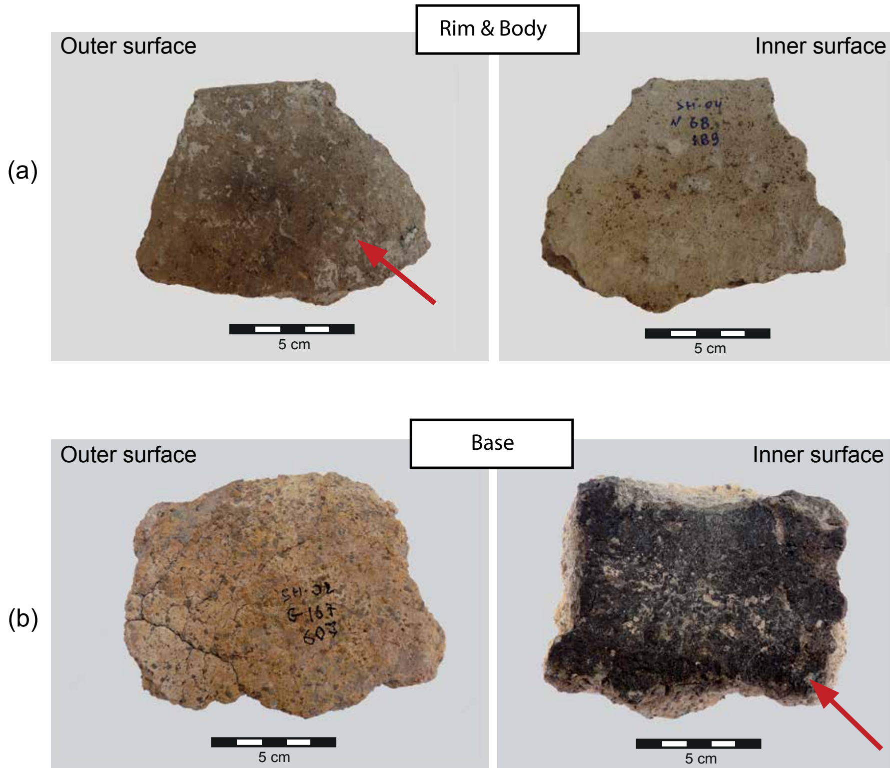

Fig. 22.4 Different use-wears identified on the Neolithic pots. a black-brownish soot deposits on the outer surface of the ceramic vessels; b charred crusts preserved on the inner surface.

(a)

Use-wear type	Nbre of sherds (%)	Criteria	Variables	Nbre of sherds (%)
Inner charred residues	111 (100%)	**Extent**	Limited	2 (2%)
			Partial	18 (16%)
			Covering	91 (82%)
		Color	Brown	1 (1%)
			Grey	1 (1%)
			Black	109 (98%)
		Surface regularity (documented only for food crusts visible on the surface)	Regular	1
			Irregular	4
		Adhesion (documented only for food crusts visible on the surface)	Weak	4
			Strong	1
		Gloss (documented only for food crusts visible on the surface)	Matt	5
			Glossy	0

(b)

Use-wear type	Nbre of sherds (%)	Criteria	Variables	Nbre of sherds (%)
Outer soot deposits	46 (100%)	**Extent**	**Limited**	13 (28%)
			Partial	8 (17%)
			Covering	25 (55%)
		Color	**Brown**	8 (17%)
			Grey	4 (9%)
			Black	34 (74%)

Table 22.3 Quantitative data related to the different use-wears identified on the surfaces of the Neolithic cooking pots from Sha'ar hagolan and Munhata: a Inner charred residues; b Outer soot deposits

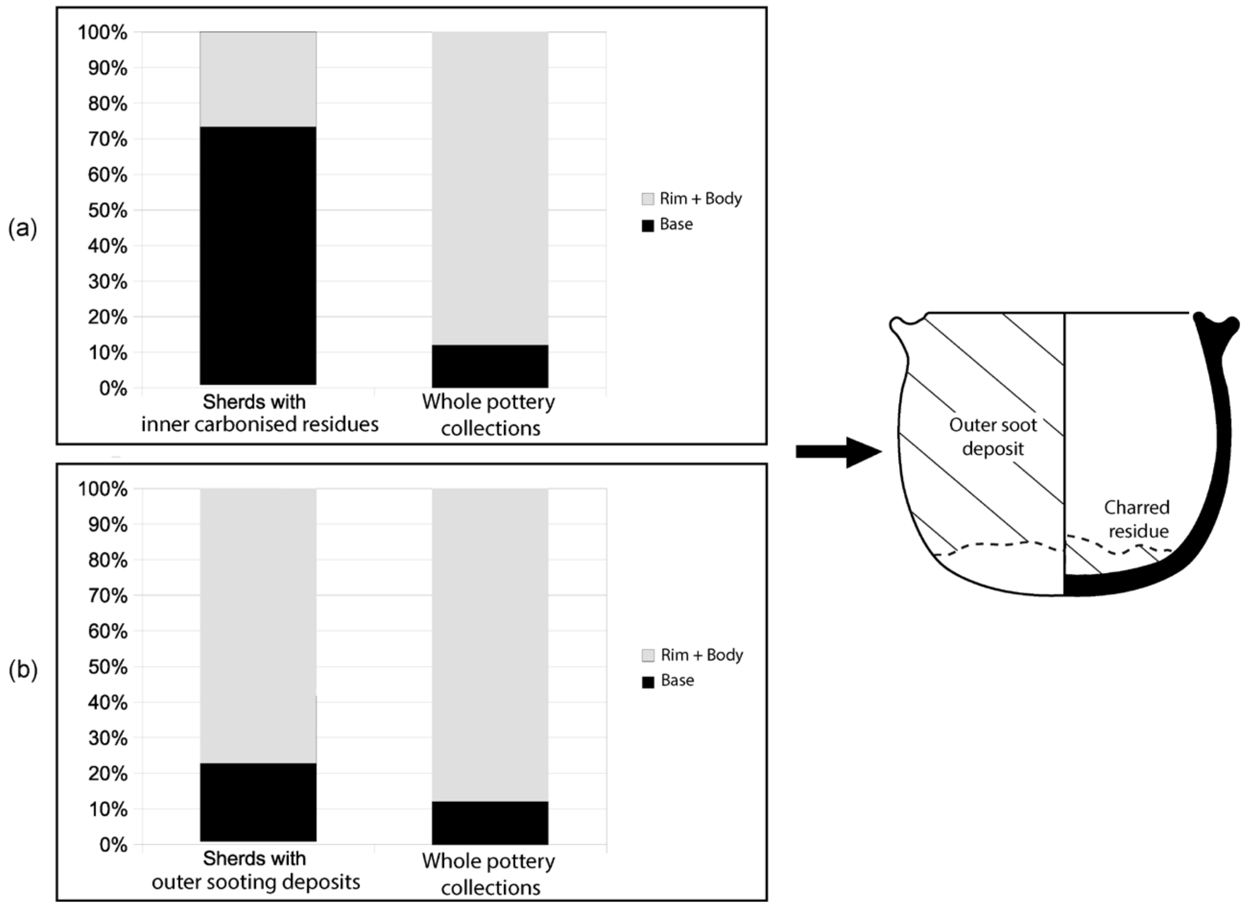

Fig. 22.5 Distribution of carbonized traces on the surfaces of Yarmukian pottery from Shaar hagolan and Munhata. a Location of the inner charred residues; b Location of the outer soot deposits.

The micro-botanical remains extracted from the 5 analyzed cooking pots are, almost exclusively, from charred crusts (A samples) and carbonized matter having permeated into the porous wall of ceramic vessels (B samples) (Table 22.4). This observation suggests that the phytoliths and starch found in these ancient pots primarily corresponds to the remains of plants that were originally cooked inside the Yarmukian pottery. It reveals that the contribution of plant remains that were naturally present in the raw clayey material used to manufacture these ceramic vessels is very minor. It also demonstrates that the contribution of phytoliths and starch during the burial of the archaeological remains (possible transfer of micro-botanical remains from the sediment to the artefacts) and during the post-excavation treatment of the pottery sherds (possible transfer of micro-botanical remains when they were washed) remains very limited in the case study presented here. Otherwise, the phytoliths and starch would have been found on both surfaces of the 5 sherds in a large amount. The micro-botanical remains found in the 5 pottery sherds from Sha'ar Hagolan represent therefore plant remains of unambiguous origin (class A, according to Hubbard and Clapham 1992).

Trapped during the use of the cooking pots, such phytoliths and starch raise the following question: What types of plants were cooked in the Yarmukian pottery? A range of monocotyledon phytolith types were recovered from the charred residues (A) and interior sherd fabrics (B) of 4 cooking pots (Table 22.4, Fig. 22.6). It includes:

- *Husk Multi-Cells forms* which is by far the main type of phytolith identified in three of the pottery sampled (no SHA_CS2158.1; SHA_CS3093.1 and SHA_CS3979.1).
- *Multi-cell dendritic forms* that compare favorably with barley and wheat type husks were also recovered in two of these vessels (no SHA_CS2158.1; SHA_CS138.1). The designation of barley and wheat is based on several characteristics as outlined in Rosen's pioneering study (Rosen 1992), primarily wave pattern and amplitude as well as the number of pits around the papillae.
- *Psilate Multi-Cells form* recovered from 1 ceramic vessel (no SHA_CS2158.1).

Micro-botanical remains	Sample number														
	Vessel No SHA-CS2158.1			Vessel No SHA-CS3093.1			Vessel No SHA-CS138.1			Vessel No SHA-CS2206.1			Vessel No SHA-CS3979.1		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Phytoliths															
Dentritic SC									x						
Echinate SC		x													
Psilate MC	x														
Husk MC	xx			xx	x									xx	
cf. Barley type	x	x													
cf. Wheat type								x							
Unidentified MC	x	x													
Starches															
Type A1							x	xxx	x		x		x		
Type A2	xx	x		x							x			xx	
Type A3				xx				xx		x	x			x	
Type B1								xx							
Type B2							x			x					
Type C1	x														
Damaged Unided							x						x	xx	
Other botanical remains															
Pollen cf. Poaceae					x										

Table 22.4 Preliminary quantitative analysis of micro-botanical remains extracted from the inner charred residues of five cooking pots from Sha'ar Hagolan: X: 1; XX: 2-5; XXX: more than 5.

- *Unidentified Multi-Cells form* identified in 1 ceramic vessel (no SHA_CS2158.1).
- *Echinate Single-Cell form* extracted from 1 ceramic vessel (no SHA_CS2158.1).

A range of starch types were in parallel recovered from the charred residues (A) and interior sherd fabric (B) of the 5 cooking pots. They are described as follows (Fig. 22.6b):

- *A Type: Simple round shape recovered from 5 vessels* (no SHA_CS2158.1; SHA_CS3093.1; SHA_CS138.1; SHA_CS2206.1; SHA_CS3979.1).
- A1: Simple granule, centric hilum, lenticular shape, under 10 microns, hilum missing (donut). Might be damaged starch, but could also be another type of crystalline structure (e.g. diatom or spherulite) (no SHA_CS138.1; SHA_CS2206.1; SHA_CS3979.1).
- A2: Simple granule, centric hilum, lenticular shape, around 10-20 microns, hilum sometimes missing (donut) (no SHA_CS2158.1; SHA_CS3093.1; SHA_CS2206.1; SHA_CS3979.1).
- A3: Simple granule, centric hilum, lenticular shape, usually around 20 microns, quite damaged, looks like it has almost mineralized and is now dissolving (no SHA_CS3093.1; SHA_CS138.1; SHA_CS2206.1; SHA_CS3979.1).

It is possible that some of the A Type starch represent *Aegilops*, Hordeum and Triticum starch that are related to cereals.

- *B Type: Simple oval shape found in 2 pots* (no SHA_CS138.1; SHA_CS2206.1);
- B1: Oval, hilum position unclear, over 20 microns in length, around 5 microns in width (cf. *Quercus boisseri* starch, however with only one example, this is only an observation of note, not an identification) (no SHA_CS138.1).
- B2: Oval, centric hilum, over 20 microns in length, around 10-15 microns in width (no SHA_CS138.1; SHA_CS2206.1).
- It is clear that several types of starchy rich resources, potentially including acorns, were cooked in these vessels.
- *C Type: Compound or semi-compound recovered from 1 vessel* (no SHA_CS2158.1)
- C1: Aggregate granules, some curved surfaces, some pressure facets. Centric hilum. Individual granules under 5 microns. Many of the wild grasses in the region have starch grains that are similar, including *Lolium multiflorum*, *L. ridgidum*, *Phalaris minor*, *P. paradoxa*, *Phleum montanum* and *Piptatherum hociform*.

By combining phytoliths and starch evidence, we can assume with a high degree of confidence that at least some of the

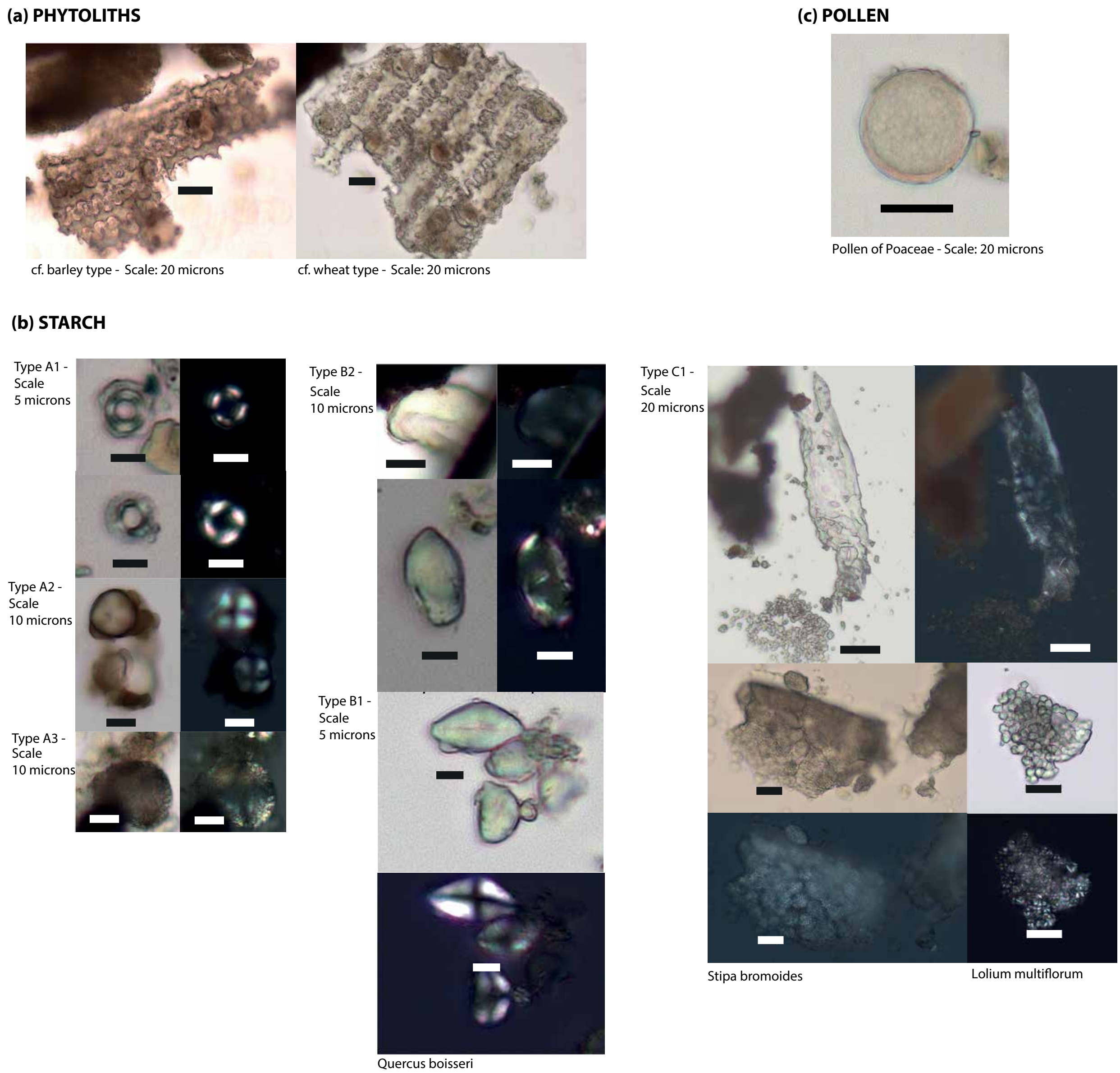

Fig. 22.6 Micro-botanical remains extracted from inner charred residues of cooking pots from Shaar Hagolan. a Phytoliths - Barley type extracted from SHA-CS2158.1b and Wheat type extracted from SHA-CS138.1b; b Starch - Type A1 & A3 extracted from SHA-CS138.1b; Type A2 extracted from SHA-CS2206.1b; Type B1 extracted from SHA-CS138.1b; Type B2 extracted from SHA-CS138.1a; Type C1 extracted from SHA-CS2158.1a; c Pollen of Poaceae extracted from SHA-CS3093.1b.

cooking pots from Sha'ar Hagolan were used for making cereal porridges with barley and wheat. The recovery of a single Poaceae pollen grain also adds support to this interpretation (Fig. 22.6c). Interestingly, archaeobotanical studies have shown that wheat and barley were by far the two most important species of domesticated plants cultivated by the Yarmukian populations (Allen 2002; Kislev and Hartmann 2012). Based on the analysis of phytoliths and starch found in the ceramic vessels, we can also suspect that the cooking pots from Sha'ar Hagolan were also used to heat wild grasses and fruits. Archaeobotanical studies have also revealed the gathering of such plants by the Yarmukian communities (Allen 2002; Kislev and Hartmann 2012). The results obtained on the micro-botanical remains trapped in the charred residues of the cooking pots from Sha'ar Hagolan are therefore consistent with those obtained from the study of scarce macro-botanical remains found in the same archaeological layers. The initial results from this limited proof-of-concept study clearly demonstrate the potential of combined starch and phytolith analysis of pottery residues to elucidate the food practices of the first pottery-making societies in the Southern Levant.

22.5 Conclusion

The multidisciplinary study of the Yarmukian cooking pots, based on the combined macro- and microscopic characterization of the outer soot deposits and the inner charred residues, revealed that the 153 fragments from cooking pots examined had not been used for frying or roasting, but for boiling foodstuffs by being placed in the center of stone hearths. Furthermore, it showed that the five vessels from which micro-botanical remains were extracted were used to cook domesticated cereals (barley and wheat) and possibly wild grasses or fruits (acorns and others). These results testify the importance of plant porridges in the daily diet of the first pottery-making societies in the Levant. Although the regular use of pottery for cooking such food preparations was suspected for these early periods, there was until now very little evidence. Lipid residue analyses carried out on more than 2000 vessels dated of the EPN in the Near East (7th mill cal BC) has so far allowed to identify plant remains only in 5 vessels discovered at the Iranian sites of Tepe Sarab (6800-6500 cal BC), Hajji Firuz (6150-5750 cal BC) and Toll e Bashi (6000-5750 cal BC) respectively (Gregg and Slater 2010). Protein analyses conducted on the calcified deposits of 10 pots from the key site of Çatal Höyük (6000-5600 cal BC) in Turkey, on the other hand, had only reveal the preparation of cereals (wheat and barley) and legumes (lentils and millets) in 5 vessels (Hendy et al 2018). Despite the limited number of cooking pots analyzed, our study thus considerably enriches the data on the topic, while highlighting the central role that ceramic vessels played in plant processing during the late 7th/early 6th mill cal BC.

The strong potential of a multi-proxy study focused on cooking pots to reconstruct the traditional recipes of the first pottery-making societies in the Southern Levant invites us to continue the research initiated in the framework of this pioneering study. We will particularly extend the study to pottery assemblages from other major EPN sites, thus allowing us to track the suspected diversity of food habits among these Neolithic communities.

Acknowledgements

The exploratory research initiated on the charred residues of Yarmukian cooking pots was undertaken in the framework of the CERASTONE project (see https://cerastone.cnrs.fr for details) funded by the French National Agency for Research (ANR no 19-CE27-0001). Further funding for the micro-botanical residue analyses was provided by a Marie Sklodowska-Curie Actions Individual Fellowship (MSCA-IF) [grant no 743544 – H-E Interactions] and a Leverhulme Early Career Fellowship [grant no ECF-2020-318] awarded to M.N. Ramsey.

We would like to thank the French Research Centre in Jerusalem, the Hebrew University of Jerusalem and the Israel Antiquities Authority for making easier the functional study of the pottery collections from the EPN sites of Sha'ar Hagolan and Munhata. In particular, we would like to express our sincere thanks to Natalia Gubenko (in charge of the Prehistoric collections at the IAA) who greatly facilitates the access to the pottery collections. We would also like to thank the University of Cambridge for allowing us to carry out the extraction of phytoliths and starch trapped in the charred residues of cooking pots from Sha'ar Hagolan.

Appendix 1

1. Clean sherd. All of the sherds were rinsed with distilled water to remove surface sediment and contaminants. They were then left loosely covered with tinfoil to dry.

2. Sample sherd. Three samples have been taken on each of the 5 selected potsherds as follow: A. charred crusts adhering to the inner surface of the cooking pots; B. interior sherd fabric where the carbonized substances have undoubtedly permeated the porous wall of the ceramic vessels and C. exterior sherd fabric where no charred residue is visible.

    a. Charred crusts. In order to minimize as much as possible the contaminations that could have been caused by the cleaning of the pottery collections prior our study, the outer surface of the charred crusts was first carefully removed. The core of these food crusts was then gently scraped onto a square of aluminum foil using a clean new steel scalpel. Micro-samples were transferred into new 50 ml centrifuge tubes.
    b. Interior sherd fabric. In order to avoid potential contaminations related the previous washing of the pottery collections, a thin layer of the potsherds was first removed. 10 mgs of sherd fabric from the inner surface of the ceramic vessels were then scraped onto a square of aluminum foil using a clean new steel scalpel. Samples were transferred into new 50 ml centrifuge tubes.
    c. Exterior sherd fabric. Same as b. In order to correctly interpret the micro-botanical remains found inside the cooking pots, we carried out an additional sample on the outer surface of each ceramic vessel. These samples were all the more essential as we unfortunately did not have any sample of sediments that were found in the immediate vicinity of the five cooking pots studied.

3. Pre-treatment and Dispersion. This step was only necessary for sherd fabric (samples b and c). It was skipped for charred residues (samples a).

a. 10 ml of 6% hydrogen peroxide (H2O2) (a weak acid) were added and the samples were left to sit and react at room temperature for 10 minutes.
b. Cold distilled water was added to the samples. They were then mixed and centrifuged at 2000 rpm for 2 minutes. This was repeated twice more, and on the final rinse most of the supernatant was pipetted off, as close to the sediment pellet as possible without disturbing it.
c. The sample was then left to sit in a little distilled water overnight to help disperse the clays.
d. The next day 15-20 ml of a dispersant (Sodium hexametaphosphate, Calgon – 50gm powder to 1 litre distilled water) were added to each sample. The samples were vigorously shaken to mix, and then placed in an orbital shaker on low for 2 hrs.
e. Enough distilled water was added to the samples to nearly fill the centrifuge tubes. They were then capped, shaken and centrifuged for 2 minutes at 2000 rpm. Samples were decanted, leaving ~ 2 cm of supernantant in the test tube. This was repeat two more times to rinse all of the Calgon from the samples.

4. SPT Flotation for Starch Grain and Phytolith Recovery and Mounting. The starches and phytoliths were extracted together with one heavy density liquid separation step. Accordingly, extraction procedures including heat in excess of 35°C and strong acids were avoided as these treatments will destroy or lose the starches. The one applied in this case study was carried out as follow:

   a. 7.5 ml of fresh (not recycled) Sodium Polytungstate (SPT, prepared to a specific gravity of 1.8) were added to each tube and mixed. The samples were then centrifuged at 800 rpm for 10 minutes. For this exploratory analysis, the SPT was prepared to focus on starch recovery, accordingly phytolith recovery is expected to be unrepresentatively low. Future analyses will include a secondary phytolith recovery step with a heavier preparation of SPT (2.3).
   b. Tubes were filled to 50 ml with distilled water, capped and mixed well to drop specific gravity, then centrifuged at 2,000 rpm for 2 minutes. One third of the supernatant was pipette off approximately. This step was repeat twice more. During the last round, most of the supernatant was pipetted off.
   c. An aliquot of the suspension was pipetted from the bottom of the extract onto a microscope slide, covered with a coverslip, and the edges secured with a drop of clear nail polish. The rest of the sampled was left in suspension in water for storage.
   d. The slides were scanned in their entirety at 20x using a Zeiss Axio research microscope with AxioVision and Zen advanced imaging software.

In future, all starch types will also be subject to lugol's iodine dye confirmation and the presence of spherulites investigated on a polarizing geological scope with rotating stage.

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Chapter 23

Cooking in Bronze Age northern Greece: an investigation of thermal structures

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Niki Chondrou, Soultana-Maria Valamoti

Abstract

The thermal treatment of food plays an important role in cooking processes, as it strongly affects its taste, texture and physico-chemical properties. Thermal structures are the loci and the means of these transformations and, thus, offer a unique source of information for approaching prehistoric cooking traditions. Following this view, we attempted to investigate the potential of cooking installations from the perspective of cooking technologies possibly developed during the Bronze Age in northern Greece (Macedonia region). Collecting this large amount of data (203 structures from 27 different sites, dating to the three periods of the Bronze Age) was a long process and their systematic analysis raised many methodological problems.

The resulting database founded on techno-morphological criteria shows a great typological diversity of structures. It appears that the majority of the structures is made of clay. The most frequent type in the EBA is the multifunctional U-shaped/oval hearth with upper opening serving as a vessel support. It diminishes in the LBA, while the circular/oval type of structures increases in number, as does a certain type of vessel, the pyraunos, adopted around the same time. Firing installations reveal chronological and regional variations in Bronze Age cooking techniques that are discussed in relation to cooking pottery styles.

Keywords: *cooking, thermal structures, Bronze Age Greece*

23.1 Introduction

Cooking is undeniably one of the most important activities performed on a daily basis in domestic contexts, as it affects people's nutrition and hence, their maintenance capacity. At the same time it forms an essential element of social, ritual and symbolic aspects of past societies. This performative task involves a material component, a cognitive asset and social etiquette. In cooking settings social groups often find the proper means to express affiliation, lineage and solidarity or to display wealth, authority and antagonism. Cooking technologies have a major social impact and power and therefore, they are promising fields of archaeological research. They offer the means to explore past culinary traditions and everyday social negotiations performed in their context that affected the cultural identity of prehistoric societies.

in: Valamoti SM, Dimoula A, Ntinou M (eds) 2022, Cooking with Plants in Ancient Europe and Beyond: Interdisciplinary approaches to the archaeology of plant foods, Leiden: Sidestone Press, pp. 407-430

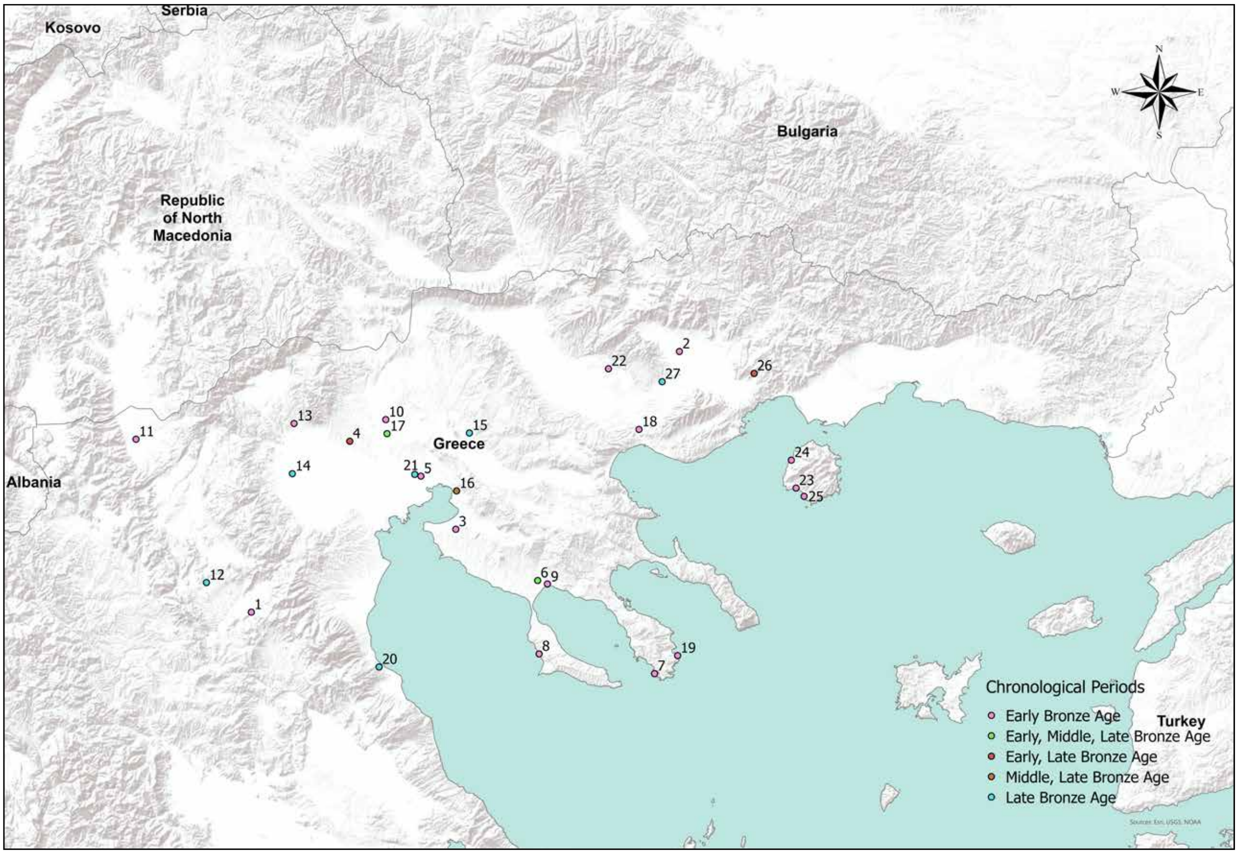

Fig. 23.1 Map of the Bronze Age sites at the Macedonia region. 1. Servia; 2. Sitagroi; 3. Mesimeriani Toumba; 4. Archontiko; 5. Agios Athanasios; 6. Agios Mamas; 7. Torone; 8. Siviri; 9. Molyvopyrgos; 10. Axiochori (Vardaroftsa); 11. Armenochori; 12. Platania (Boubousti); 13. Mandalo; 14. Angelochori; 15. Assiros; 16. Thessaloniki Toumba; 17. Kastanas; 18. Kryoneri; 19. Kriaritsi; 20. Rema Xydias; 21. Anchialos; 22. Pentapoli; 23. Limenaria; 24. Skala Sotiros; 25. Agios Antonios Potou; 26. Dikili Tash; 27. Angista.

With the aim to explore that potential the present paper investigates the cooking technologies developed at the Bronze Age settlements of northern Greece and their gradual transformation during the course of the Early, Middle and Late Bronze Age, i.e. the 3rd and 2nd mill BC. The research geographically focuses on present day Macedonia, a vast region that over time exhibited local diversities in material expressions.

The material imprint of cooking in archaeological settings in Macedonia is rather variable. In the present study we concentrate on thermal cooking installations, namely purposefully arranged spaces that are equipped with a feature destined (not necessarily exclusively) for the thermal treatment of foods. Based mainly on this evidence our analysis aims to reconstruct cooking technology in BA domestic contexts in Macedonia. As cooking encompasses various techniques and tasks it should be stated from the beginning that our intention here is to approach only the aspect of the thermal processing of foods. In the absence of an overview of the rich record of fire installations, our primary goal is to fill in this apparent gap in the relevant literature by bringing together, for the first time, all available published evidence[1]. Methodologically, the presentation and classification of the thermal features will follow specific techno-morphological criteria leading eventually to a better understanding of their thermal behavior. After all, an effort is made to assess their cooking potentials by taking into consideration also other kinds of cooking gear, cooking vessels in particular.

23.2 The study area

Hearths and ovens are a usual find in Bronze Age (3300-1050 BC) settlements in Macedonia and the increased number of excavations over the last forty years has brought to light various habitation spaces devoted to cooking activities. The compiled inventory discussed below contains 203 thermal structures and it was processed by

1 For previous efforts see Prévost 1993; Papadopoulou 2010, 420-434, 444-448.

means of a database that was especially produced for this purpose by the ERC funded project PlantCult (Valamoti et al 2017).

The data under study come from twenty seven sites (Fig. 23.1). The dominant site type of the period is the tell with multiple phases of occupation. Due to the successive rebuilding of the houses at the same location over long periods of time, tell deposits offer the possibility to detect local changes in culinary traditions, especially during transitional periods. In the Early Bronze Age (3300-1900 BC), tell sites co-exist however along with settlements of shorter duration. Those are usually established in marginal zones around plains, on hilltops, often near the sea, or on promontories (Andreou 2014, 144; Andreou 2010, 644-645). As for the Middle Bronze Age (1900-1650 BC) evidence is limited in most parts of Macedonia. With the exception of Chalkidiki and Pieria where there are attested influences from central and southern Greece, the rest of the Macedonian region remains more or less attached to its EBA traditions and the Balkan cultural trends. The only available information on MBA cooking installations comes from Kastanas, Thessaloniki Toumba and Agios Mamas.

In the Late Bronze Age (1650-1050 BC) tells dominate the Macedonian landscape with some of them acquiring considerable height due to the construction of massive terraces at their slopes, as for example Angelochori, Axiochori, Assiros and Thessaloniki Toumba. The period is also characterized by a rise in settlement numbers which is combined with the expansion of the habitation on higher elevations and the establishment of a hierarchical network of sites (Andreou 2010, 649; Andreou et al 1996, 578, 585, 587). Storage and redistribution practices basically of crops and foodstuffs have been very popular in theoretical proposals trying to account for rising social inequalities and hierarchies that become apparent in LBA communities.

23.3 The dataset: methodological considerations

Taken into consideration the diversity of the thermal features and the disparate body of information that had to be assembled, a series of methodological problems arose during the design of the database and the recording process. To begin with, the data of the study had to be obtained from various published works, some of preliminary and others of final and detailed character, a fact that, by extension, led to the concentration of an uneven quantity and quality of information. Hence, for some sites we had at our disposition minute descriptions, measurements and designs of the thermal structures, whereas in others the mere mention of their presence in a space. In order to circumvent this problem, we decided to enter all referenced structures in the database, so as to evaluate them quantitatively. However, those that did

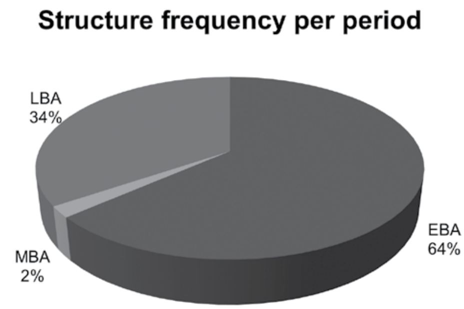

Fig. 23.2 Pie chart depicting the frequency of thermal structures at each period.

not possess sufficient information on their morphology, dimensions or construction technique were excluded from the relevant statistical analysis.

Another methodological issue raised during the recording phase was the problem of the terminology (Papadopoulou 2010, 91-94). The lack of a standardized terminology, based on techno-morphological qualities and discrete criteria, has often led to a chaotic fusion of information that usually fails to render field reality. For instance, the same type of installation may be assigned dissimilar definitions at different sites, a fact that obstructs the formation of typologies and the identification of technological trends. Another observed tendency in the publications is the misuse of the functional terms hearth and oven. These terms point to an open or closed firing environment respectively which can be achieved, in both cases, by a variety of structures (Papadopoulou and Prévost-Dermarkar 2007, 127; Prévost-Dermarkar 2002, 223-232). As a consequence the wide application of the hearth/oven designation obscures in many cases fire structure variability.

In order to address these critical questions, we decided in the first place to gather for any structure all available published information regarding its techno-morphology[2]. This information was systematized according to the following criteria: a. plan shape, b. presence or absence of framing, c. the structure's floor relationship to the ground level, d. the construction technique of the floor, e. the framing/wall profile, f. the presence of an entrance and its orientation, g. construction technique of the framing/wall, h. decorative features. All mentioned dimensional measurements related to the above structural parts were also registered. The database was furthermore

2 For examples of previous terminologies adopted in other geographical areas and/or time periods, see Deshayes 1974; Leroi-Gourhan 1979; Molist 1986, 11-13; Petrasch 1986; Kalogiropoulou 2013, 76-79.

supplied with spatial, contextual and preservation related information regarding each individual structure.

23.4 Data analysis

As has been mentioned the database contains 203 structures from twenty seven different sites. However, the absolute number of thermal structures that have been revealed in the excavations is admittedly much higher than the actual published examples. The EBA period is represented at twenty sites, the MBA at only three and the LBA at ten (Fig. 23.1). Although the EBA sites significantly outnumber the LBA sites, it is noteworthy that in certain tells the extent of the excavated LBA habitation layers is significantly higher.

The chronological distribution of the thermal structures reveals that two thirds (64%) come from EBA contexts, a slim percent (2%) from MBA and the rest (34%) from LBA (Fig. 23.2). At first sight this tendency appears to be the outcome of the overrepresentation of the EBA, as 59% of the sites have habitation layers that date to the 3rd mill.

The state of preservation of the thermal structures at the Macedonian sites we have examined is rather mediocre, as usually the floor of the structure survives, whereas the clay superstructure, due to its fragile nature, demonstrates severe damages. Inevitably, estimations about the degree of the structures' preservation were necessarily based on their published plans. According to this criterion only 17% of the assemblage has a fully and 52% a partially preserved ground plan. As frustrating as these results may be, they obtain another dimension if we take into consideration that for 31% of the structures we have no published information about their degree of preservation. In general however, one has to admit that BA thermal features are poorly preserved at Macedonian sites.

23.4.1 Thermal structure typology and technological attributes

For the purposes of the study the thermal features have been divided in two large categories: the fire features that display no permanently built elements and the structured features that dispose more or less fix constructed parts.

In settlement deposits, areas that are characterized by thermally altered sediments, charcoal fragments, ash and other burnt materials, organic or not, are often interpreted as the remnants of open fires. These fire areas may be related to various activities, other than cooking, therefore their culinary function has to be supported by further contextual evidence and/or special analysis[3].

The structured features are difficult to classify as they display great variability. The first criterion used for their classification was the correlation of the firing surface to the ground level. This led to the identification of two wide groups: A. above-ground structures and B. pit structures. In the case of type A structures the fire was set on, close to or occasionally higher than the soil surface. Clay structures with floors founded in shallow pits were also included in this category provided their use surface was placed on ground level. As type B structures we characterized all dug-out formations, pits or shallow depressions wherein fires were lit (Fig. 23.3).

The above-ground installations constitute the majority of the studied material. The first step taken for their classification was to group them into stone built (type A.1) and clay installations (type A.2), according to the prevalent material used for their construction. The clay structures were furthermore subdivided in single (type A.2.1) and multiple (type A.2.2) room structures. Based on specific technical traits, we finally proceeded with the discrimination of sub-groups (Fig. 23.3).

By adopting this typological scheme that is based on techno-morphological attributes, we tried to sidestep the eternal dilemma, hearth or oven, a choice that apparently conceals technological diversity and carries a latent functional predetermination. Furthermore, the proposed typology is potentially liable to extensions and additions of new categories and is susceptible to incorporating even poorly preserved installations.

23.4.2 Presentation of the archaeological assemblage

The EBA period is represented by 129 thermal structures, while the LBA by 70. The limited number of four structures attributed to the MBA allows only a few suggestions (Fig. 23.2, Tables 23.2-4). The quantitative distribution of the structures at each site per period is depicted in Fig. 23.4.

23.4.2.1 Non structured thermal features

Non structured fire features are extremely rare in EBA settlement contexts at Macedonia, since only one example has been so far reported. It comes from late EBA Armenochori and it consists of an accumulation of ashes found on an exterior space, probably sheltered, where a lot of animal bones were disposed (Chrysostomou 1998, 342). In the LBA, fire features remain equally rare, as only one probable example is reported from Final LBA Thessaloniki Toumba. It is described as a burnt stain on the floor III of room A3 with burnt sherds of cooking pots around (Karadimou 1999, 84).

23.4.2.2 Structured thermal features

A. Above ground structures

In the EBA period, the above-ground thermal structures correspond to 124 examples, forming thus 96% of the assemblage. The sub-group of the clay made features clearly constitutes the dominant trend of the period with

3 Various analytical methods have been applied to the study of open fire features. For an exhaustive overview see Mentzer 2014 and also Aldeias et al 2016; Friesem 2018.

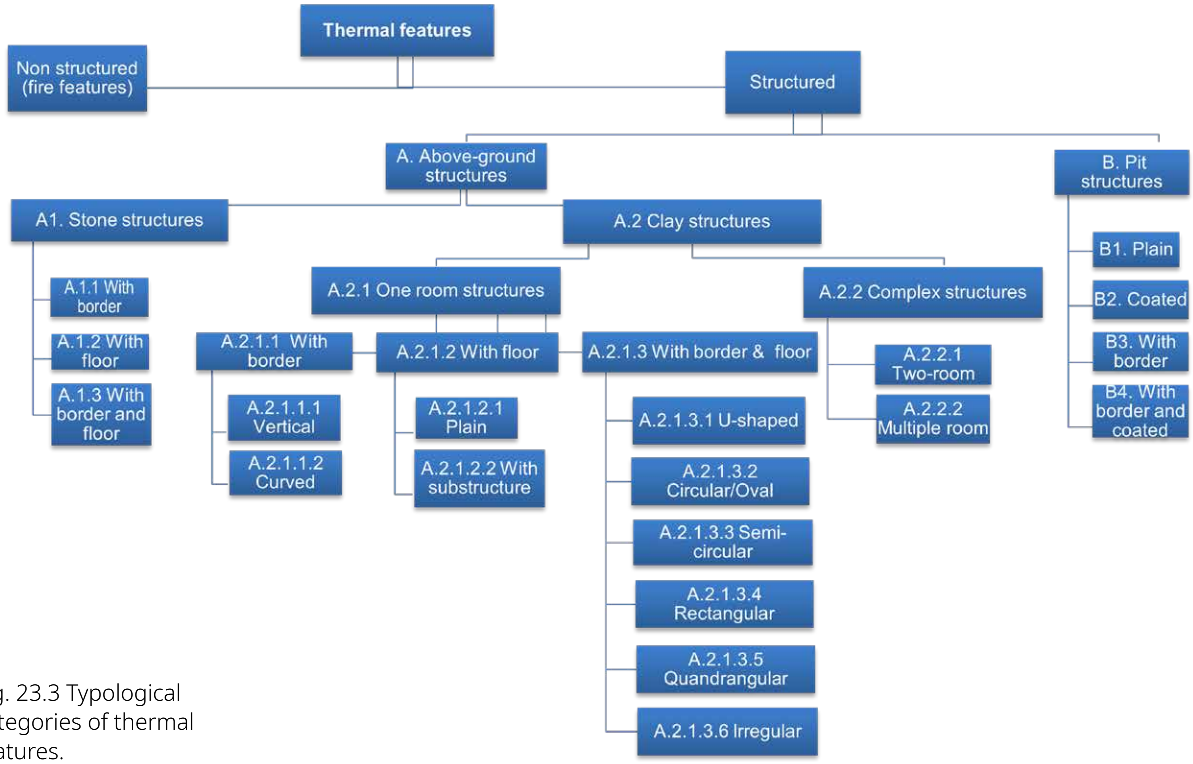

Fig. 23.3 Typological categories of thermal features.

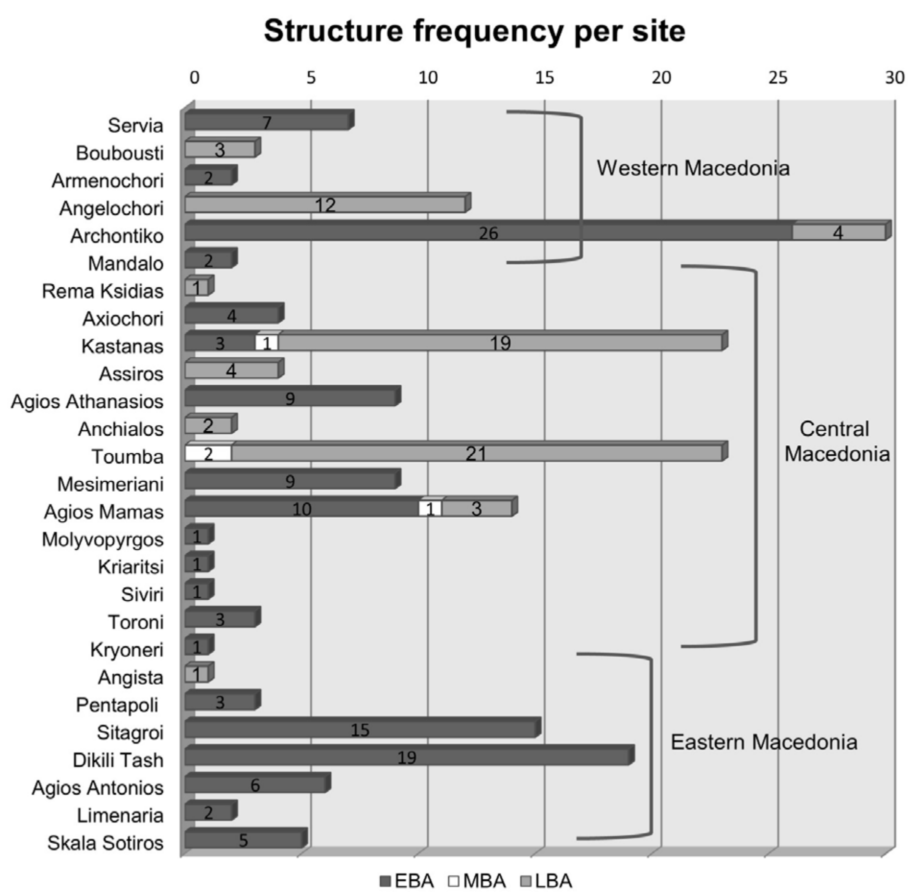

Fig. 23.4 Frequency distribution of thermal structures at individual sites per period.

Structure type						Total number
A1. Stone structures	A.1.1 Structures with border	EBA			Vardaroftsa 5-7 (Heurtley and Hutchinson 1925/1926, 41, fig. 26-28), Mesimeriani 5 (Grammenos and Kotsos 2002, 128), Agios Mamas (Heurtley 1939, 5, fig. 5c), Kriaritsi (Asouhidou et al 2000, 333), Dikili Tash IIIA-B/S24-5 and R25-4 (Treuil 1992, 50, pl. 37A, Sérfiadès 1983, 657), Agios Antonios (Papadopoulos et al 2011, 517-518, fig. 4), Limenaria (Malamidou and Papadopoulos 1997, 586, fig. 2)	11
		LBA			Archontiko I (unpublished), Toumba Thessaloniki IV (Karadimou 1999, 70, 83, 122)	5
	A.1.2 Structures with floor	EBA			Servia 9/ features PP, QQ and one in structure 2 (Heurtley 1939, 55, fig. 46; Mould and Wardle 2000, 60, 93)	3
		LBA			Toumba Thessaloniki IV (Karadimou 1999, 57)	1
	A.1.3 Structures with border and floor	EBA			Dikili Tash IIIB/ S24-1 and S24-2 (Treuil 1992, 29, 50, pl. 37C-D)	2
A2. Clay structures/ A2.1 Single firing space	A.2.1.1 Structures with border	EBA			Sitagroi IV and V (Renfrew 1986, 187, 189, 191, 205, 208, 210 and pl. XX2, XXIV2 and XXIX3)	8
		LBA			Kastanas V (Hänsel 1989, 183, fig. 67, 73, 74, pl. 25.2), Toumba Thessaloniki IV (Karadimou 1999, 157)	2
	A.2.1.2 Structures with floor	EBA			Agios Athanasios 1-2/ E3, E10, E13 and E16 (Mavroidi 2012, 38-39, 55-56, 69, 76-77), Mesimeriani 4 (Grammenos and Kotsos 2002, 63)	5
		MBA			Kastanas II (Aslanis 1985, 60, fig. 28)	1
		LBA			Boubousti 1 (Heurtley 1939, 40), Kastanas V (Hänsel 1989, 176, fig. 70)	2
	A.2.1.3 Structures with border and floor	EBA	U-shape		Servia 9 (Mould and Wardle 2000, 61, pl. 2.7a), Sitagroi Va/ oven 1 (Renfrew 1986, 191, fig. 8.12), Mesimeriani 3-4 (Grammenos and Kotsos 2002, 62, 75), Archontiko II-IV/ pk 1, 5, 6, 8, 9, 10, 19, 31, 32, 36, 58, 68, 69, 84, 90, 92 (Papadopoulou 2010, 167-172), Agios Mamas I (Hänsel and Aslanis 2010, 67-68, 76-78, 85), Kastanas Ia (Aslanis 1985, 56-57)	27
			Circular	with entrance	Mesimeriani 5 (Grammenos and Kotsos 2002, 960), Agios Mamas I (Heurtley 1939, 5-7)	15
				without entrance	Mesimeriani 2 (Grammenos and Kotsos, 2002, 57-58), Agios Athanasios/ E2 (Mavroidi 2012, 55, 75-76, fig. 4), Agios Mamas I (Hänsel and Aslanis 2010, 67, 76), Armenochori 3 (Heurtley 1939, 59, fig. 55-56), Mandalo III (Pilali-Papasteriou et al 1986, 455), Kastanas Ia (Aslanis 1985, 24, fig. 8), Skala Sotiros (Papadopoulos et al 2007, 428, sx. 2), Dikili Tash IIIA/ T24-3 (Treuil 1992, 28, 50, pl. 37F).	
			Oval	with entrance	Archontiko IV/ pk 26 (Papadopoulou 2010, 214-215, 170, fig. 5.5, appendix I: pk 26)	5
				without entrance	Agios Athanasios 1 and 2/ E1, K7, E5 and one in space H3 (Mavroidi 2012, 39-40, 54-55, 68, 71)	
			Semi-circular		Mesimeriani 6 (Grammenos and Kotsos 2002, 101)	1
		MBA	Circular		Agios Mamas II (Hänsel and Aslanis 2010, 141)	1
		LBA	U-shape		Angelochori II (Stefani 2010, 139-141 and fig. 4.2.13, 4.2.20, 4.2.7), Kastanas V (Hänsel 1989, 157-158 and fig. 55-56), Archontiko I (Papaefthymiou-Papanthimou and Pilali-Papasteriou 1994, 84, fig. 2), Anchialos (Tiverios 1992, 357-358 and fig.1), Toumba Thessaloniki IV (Andreou et al 2010, 360, fig. 1B)	7
			Circular	with entrance	Boubousti 2 (Heurtley 1939, 43), Kastanas IV-V (Hänsel 1989, 111, 156-157, 183 and fig. 36, 55-57, 67, 73-74)	16
				without entrance	Agios Mamas IV (Hänsel and Aslanis 2010, 198), Bouboutsi 1 (Heurtley 1939, 40-43), Assiros 7 (Wardle 1987, 323), Thessaloniki Toumba IV (Andreou et al 2010, 360), Kastanas III-V (Hänsel 1989, 68, 81-82, 113, 143, 167, 165, 183)	
			Oval	with entrance	Angista (Koukouli-Chryssanthaki 1980, 56)	3
				without entrance	Archontiko I (Papaefthymiou-Papanthimou and Pilali-Papasteriou 1994, 84, fig. 3), Kastanas V (Hänsel 1989, 165)	
			Semi-circular		Agios Mamas IV (Hänsel and Aslanis 2010, 218)	1
			Rectangular/ Quadrangular		Agios Mamas IV (Hänsel and Aslanis 2010, 241, 247-248, plan on Beilage 8), Kastanas V (Hänsel 1989, 183, fig.73 and pl.25.1)	2
A2. Clay structures/ A2.2 Complex structures	A.2.2.1 Two-room structures	EBA			Archontiko III-IV/ pk 7, 11, 18, 25, 33, 46, 54, 66 (Papaefthymiou et al 2007, 142-143, Papadopoulou 2010, 172-174), Sitagroi Va/ oven 2 and Sitagroi Vb/ features C/D and G/H (Renfrew 1986, 187, 191, fig. 88, pl. XXI.1, XXX-XXXI), Dikili Tash IIIA/ 6-058 (Darcque et al 2021, 408)	12
	A.2.2.2 Multiple-room structures				Archontiko III/ pk 55 (Papadopoulou et al 2007, 80, fig. 3; Papadopoulou and Maniatis 2013, 114-115)	1
B. Pit structures	B1. Plain pits	EBA			Dikili Tash IIIA/ 6-023, 6-024 (Darcque et al 2021, 408)	2
	B2. Coated pits	EBA			Sitagroi IV (Renfrew 1986, 177)	1
	B3. Pits with stones	EBA			Molyvopyrgos 2 (Heurtley 1939, 14-15)	1
		LBA			Kastanas IV (Hänsel 1989, 125, pl. 15.1)	1

Table 23.1 Typology of Bronze Age thermal structures from Macedonia.

EBA SITES	A. ABOVE-GROUND STRUCTURES									B. PIT STRUCTURES			TOTAL
	A.1 Stone structures			A.2 Clay structures									
	A.1.1.1	A.1.1.2	A.1.1.3	A.2.1.1	A.2.1.2	A.2.1.3	A.2.2.1	A.2.2.2	A.2[Unclassified]	B.1	B.2	B.3	
Agios Antonios	1					1			4				6
Agios Athanasios					4	5							9
Agios Mamas	1					9							10
Archontiko						17	8	1					26
Armenochori						1							1
Dikili Tash	2		2			2	1		10	2			19
Kastanas						2			1				3
Kryoneri									1				1
Kriaritsi	1												1
Limenaria	1								1				2
Mandalo						2							2
Mesimeriani	1				1	5			2				9
Molyvopyrgos												1	1
Pentapoli						2			1				3
Servia		3				2			2				7
Siviri									1				1
Sitagroi				8		1	3		2		1		15
Skala Sotiros						4			1				5
Toroni						1			2				3
Vardaroftsa	4												4
TOTAL	11	3	2	8	5	54	12	1	28	2	1	1	128
+1 Non-structured installation from Armenochori													

Table 23.2 Typology of thermal structures at the Early Bronze Age sites.

MBA SITES	A. ABOVE-GROUND STRUCTURES				TOTAL
	A.2 Clay structures				
	A.2.1.1	A.2.1.2	A.2.1.3	A.2[Unclassified]	
Agios Mamas			1		1
Kastanas	1				1
Toumba				2	2
TOTAL	1	0	1	2	4

Table 23.3 Typology of thermal structures at the Middle Bronze Age sites.

LBA SITES	A. ABOVE-GROUND STRUCTURES							B. Pit structures			TOTAL
	A.1 Stone structures			A.2 Clay structures							
	A.1.1.1	A.1.1.2	A.1.1.3	A.2.1.1	A.2.1.2	A.2.1.3	A.2[Unclassified]	B.1	B.2	B.3	
Agios Mamas						3					3
Anchialos						1	1				2
Angelohori						3	9				12
Angista						1					1
Archontiko	2					2					4
Assiros						3	1				4
Boubousti					1	2					3
Kastanas				1	1	14	2			1	19
Rema Ksidias							1				1
Toumba	3	1		1		5	10				20
TOTAL	5	1	0	2	2	34	24	0	0	1	69
+ 1 Non-structured installation from Toumba											

Table 23.4 Typology of thermal structures at the Late Bronze Age sites.

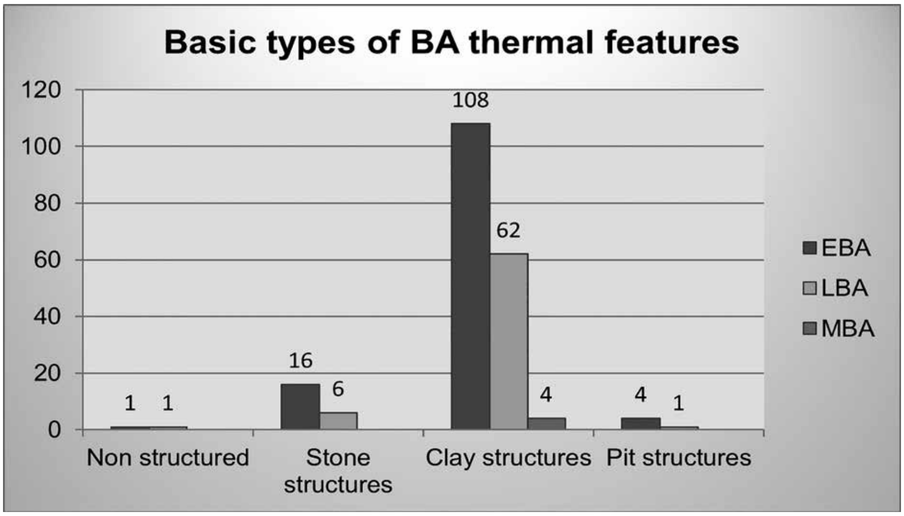

Fig. 23.5 Frequency of basic types of thermal structures in different Bronze Age periods.

108 examples, whereas only 16 belong to the stone built sub-group (Fig. 23.5).

Similar trends are also observed for the LBA period, as above-ground structures are by far the most numerous, being represented by 68 out of 69 structures (97%). As regards construction materials, only six specimens belong to the stone-built subgroup, while the rest (62) fall into the category of clay structures (Fig. 23.5).

A1. Stone structures

Hearths or ovens exclusively constructed of stone material are rare in EBA settlements (16), as they roughly represent 12% of the studied sample. In the LBA, their number diminishes further (6), reaching thus only the 9% (Fig. 23.6a-b).

In the stone-built structures stones are applied either to delineate the area around the fire or to form a paved surface where the fire is set. Generally, the stones are used unmodified and exhibit a variety of forms, ranging from rough stones, cobbles and pebbles to flat slabs. Unfortunately, we rarely encounter information about the type of the rock or the fire alterations it underwent. Tightly or loosely arranged, the stones are fixed as a rule without connective mortar, except probably for LBA Thessaloniki Toumba where clay is used. The techniques applied are simple and minimal, yet effective, as the stone border prohibits the dispersal of the charcoals and the paved or cobbled floor limits thermal losses and accumulates heat. Based on morphological features, three general types are detected:

A.1.1 Structures with stone border

This is the most popular stone-built category in the EBA (Fig. 23.7, Table 23.1). It consists of an earthen floor and a frame composed of one layer of stones set directly on the ground. The outline of the stone border may be circular (Mesimeriani, Dikili Tash), semi-circular (Agios Mamas), elliptical (Agios Antonios Potou), rectangular (Kriaritsi) or irregular (Vardaroftsa) (Fig. 23.8a). Little can be said about their dimensions, as only in one case we have available information.[4]

Archontiko I (Early LBA) and Thessaloniki Toumba IV (Final LBA, Building A, rooms A2, A3 and A6, see Karadimou 1999, 70, 83, 122) offer the only LBA stone bordered fire installations (Fig. 23.7, Table 23.1). As in the EBA period, the border consists of stones, although in one case at Thessaloniki Toumba large sherds were also added. Their shapes were circular, semi-circular or irregular.

A.1.2. Structures with a stone floor

This particular type incorporates structures with paved floors and no framing (Fig. 23.7, Table 23.1). It is known from EBA Servia where two features (PP and QQ) consisting of a roughly circular floor with cobbles were found by Heurtley, while another one is reported from the later excavations (Mould and Wardle 2000, 60). Heurtley (1939, 55 and fig. 46) informs us that one of them was made of rough limestone blocks and measured 0.80m in diameter. Nearby, the bases of two cooking pots stood *in situ* and a pocket of soft black earth spread along (Fig. 23.8b). In our view, there is a high possibility that the PP and QQ features are the remnants of clay structures, namely the stone bedding of their floors which was originally covered with a clay plaster that was destroyed. After all, this technique was quite familiar to the inhabitants of EBA Servia (Mould and Wardle 2000, 60, 95).

For the LBA, only one stone floor structure is attested at Final LBA Thessaloniki Toumba IV (Fig. 23.7, Table 23.1). The discovered feature had a flat stone base covered by a white layer (ashes?) of oval shape (Karadimou 1999, 57).

4 This is Agios Antonios Potou, where the preserved structure measures 1.8 X 1.4m (Papadopoulos et al 2011, 517-518 and fig. 4).

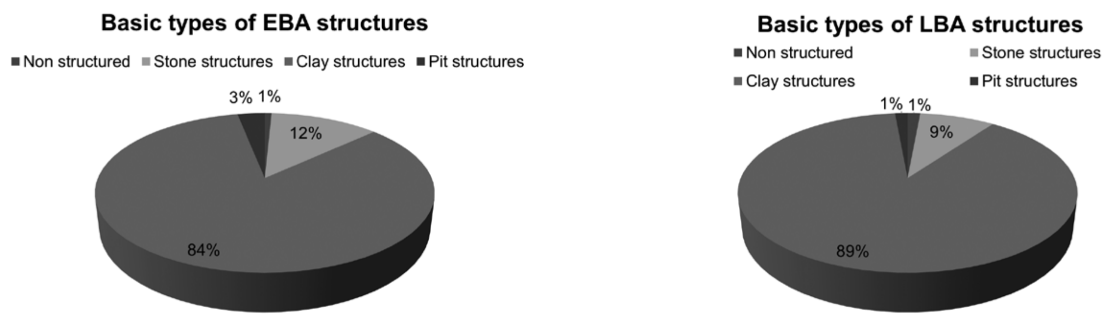

Fig. 23.6 Percentage of basic types of thermal structures. a in the Early Bronze Age; b in the Late Bronze Age period.

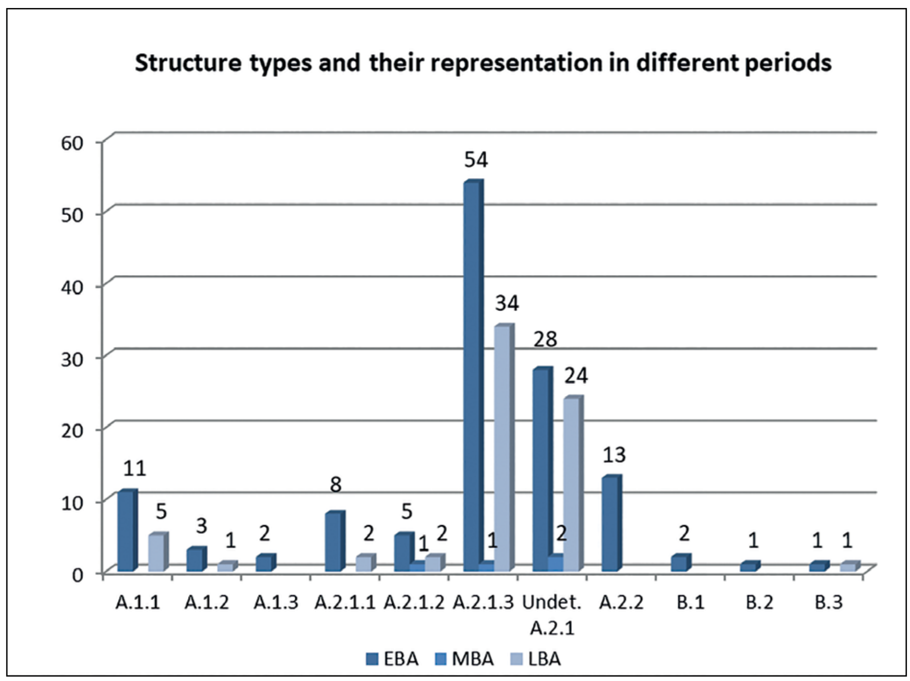

Fig. 23.7 Types of thermal structures and their representation in different Bronze Age periods.

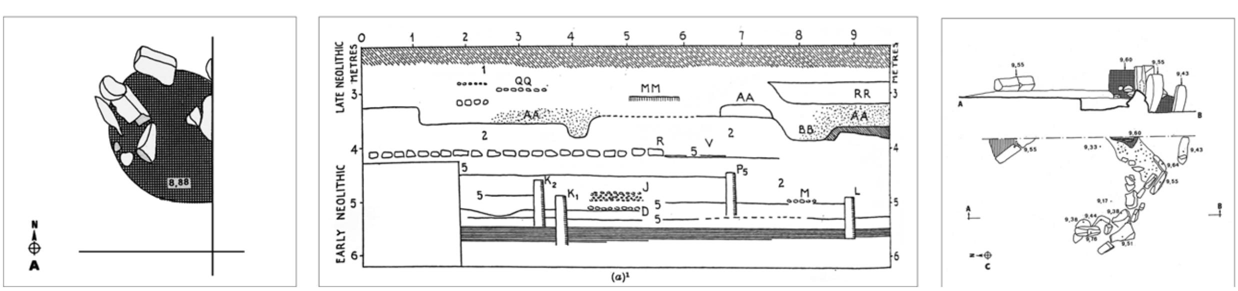

Fig. 23.8 Stone built thermal structures. a type A.1.1 from EBA Dikili Tash (S 24-2, after Treuil 1992, planche 37a); b type A.1.2 from EBA Servia (feature QQ in cross section, after Heurtley 1939, figure 46); c type A.1.3 from EBA Dikili Tash (S 24-2, after Treuil 1992, planche 37c).

A.1.3. Structures with a stone border and floor

The only two recorded examples of this type come from EBA Dikili Tash IIIB (Fig. 23.7, Table 23.1). The first one (S24-1) consists of a more or less semi-circular stone border which was set around a layer of clay coated stones (1.10 x 0.70m), whereas the second one (S24-2) possesses a rim of stones, probably arranged in a rectangular plan, and a floor composed of stones (Treuil 1992, 29, 50, pl. 37C-D) (Fig. 23.8c).

A.2 Clay structures

During the BA, clay is the material used par excellence for the construction of the fire installations. The analyses conducted so far on their clay materials have revealed that the hearth/oven manufacturers practiced particular choices in order to develop clay recipes with specific qualities (Papadopoulou 2010, 192-202; Germain-Vallée et al 2011; Papadopoulou and Maniatis 2013; Prévost-Dermarkar 2019, 15-27, 42-45).

As far as the construction techniques are concerned, although they were more or less common over the vast area of Macedonia, they were applied freely, in different combinations and variations. For instance, the study of the floor construction methods in the EBA period has shown that in 95 out of the 108 clay structures the floors were founded on ground level and only in 9 cases they were set in a shallow pit (Mould and Wardle 2000, 61; Mavroidi 2012, 38-40, 54-56, 75-76; Treuil 1992, 29, 51). During the LBA period, however, all structures were founded on ground level.

The simplest floor version, attested in most BA sites, consists of a clay layer, a few centimeters thick that is occasionally burnished (Fig. 23.9a-b). Another floor variation, which is also quite common, is characterized by the presence of a sub-structure beneath the clay firing surface that enhances the thermal insulation properties of the installation. This sub-structure reveals great technical variability, as it may consist of a single or multiple layers of sherds, pebbles, slabs, packed clay or various combinations of these materials. Sometimes, ashes or sand may also be used (Fig. 23.9c-d). In the LBA, mudbricks make their appearance, as there is an oven sub-structure from Angelochori constructed of mudbricks, pebbles, sand and clay (Stefani 2010, 139-140, fig. 4.2.13). The sub-structures are usually founded on the ground and more rarely in a shallow pit. It is worth mentioning that in the EBA 8 out of the 9 floors characterized in publications as "underground", actually had a sub-structure (Agios Athanasios, Dikili Tash). This pattern suggests that the pit is related to the sub-structure's construction and it should not thus be connected, as it is sometimes erroneously done, to a subterranean functional mode of the structure.

The techniques applied for the construction of the walls are rarely reported. Nevertheless, it has been possible to identify the use of the coil, the slab and the wattle-and-daub technique (Papadopoulou 2010, 204-209; Prévost-Dermarkar 2003, 218, 220-221). Of course, combinations of these different techniques may be applied for the fabrication of a singular structure. Throughout the course of the BA the two first techniques remained the prevalent modes of constructing clay structures (Fig. 23.10a). The wattle-and-daub technique, although it was known, it was used only occasionally. For example, at EBA Servia and Final LBA Kastanas, small post-holes probably represent a wattle frame that served as the supporting device for the vault's clay covering (Mould and Wardle 2000, 61, 93; Hänsel 1989, 156-157, fig. 55-57, pl. 19.2).

The use of mudbrick for the construction of structure borders is extremely rare in the EBA. There is only one exceptional case at Torone, where mudbrick in combination with small stones composed a structure's wall (Morris 2009/2010, 10, 13). Mudbricks become more common in the LBA, but still they remain rare, as we have recorded in total only five cases: two at Kastanas V (Hänsel 1989, 183, fig. 67, 72-74, pl. 25.2) and Assiros 7 (Wardle 1987, 323), respectively, and one at Thessaloniki Toumba IV (Karadimou 1999, 147) (Fig. 23.10b).

In the EBA period the clay structures are represented by 108 examples, corresponding to 84% of the assemblage. Their vast majority, namely 95, concerns single firing space installations, whereas eleven (13) specimens display more complex articulation and more than one structural compartment. All MBA and the majority of the LBA fire installations are made of clay and belong to the single space type (Fig. 23.5).

A.2.1. Structures with a single firing space

Three basic types have been identified based on the presence or absence of a clay border and clay floor (Fig. 23.3). However, a considerable number of structures (54), namely 33.5%, was not possible to be classified in more detailed groups due to the lack of published information or because of the structure's poor preservation state (Fig. 23.7).

The layout of most of the EBA unclassified structures is unknown, except for eight that were of circular or oval outline. There is no information on the presence of a border, while almost half of them disposed a floor sub-layer. The unclassified MBA data come from Thessaloniki Toumba. In the trench 032, opened at the western slope of the tell, excavations recovered probable outdoor spaces with firing installations along with finds related to cooking and food consumption (phase 12 and 9) or to artisanal activities (phase 11) (Veropoulidou 2011, 351-352, Veropoulidou et al 2005, 180-181, fig. 2). Although, there are references to kilns, a small oven and a hearth, there are no descriptions of their forms

Fig. 23.9 Construction details from clay structures' floors. a upper surface of a burnished clay floor from EBA Archontiko (pk 31); b LBA Kastanas (layer 13, Ofenhalle, after Hänsel 1989, Tafel 20.1); c floor sub-layer consisting of sherds, EBA Archontiko (pk 68); d floor sub-layer with pebbles, flat stones and sherds from EBA Skala Sotiros (after Papadopoulos 2007, figure 5).

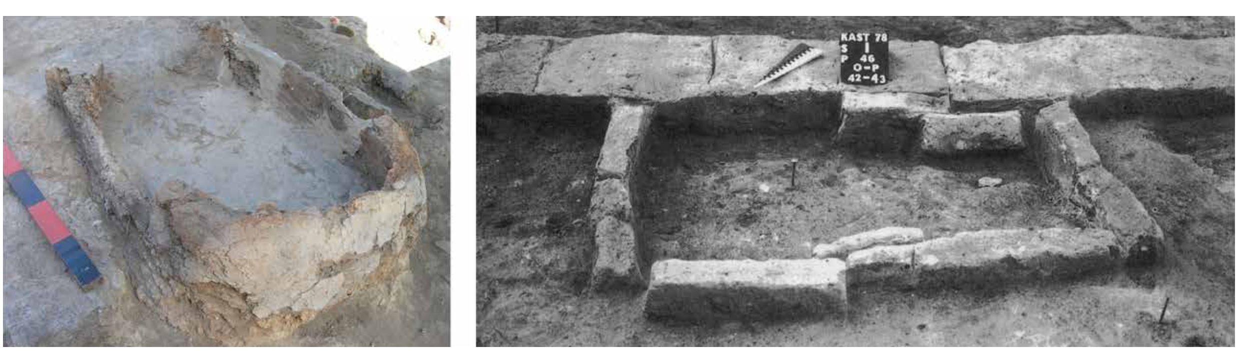

Fig. 23.10 Construction details from clay structures' walls. a the walls were formed from adjoined slabs of clay set in two superimposed rows and then their surfaces, both interior and exterior, were covered with plaster. EBA Archontiko (pk 36); b mudbrick used for the construction of the structure's frame. LBA Kastanas (layer 12, Nordhof, after Hänsel 1989, Tafel 20.3).

and construction techniques. The unclassified LBA clay structures are characterized by a variety of shapes with the circular being the most common (Fig. 23.7).

A.2.1.1 Structures with a clay border

Structures disposing only a border are rare in EBA and LBA contexts alike (8 and 5% respectively). All EBA examples come from Sitagroi IV and V (Renfrew 1986, 187, 189, 191, 205, 208, 210 and pl. XX2, XXIV2 and XXIX3) (Fig. 23.7, Table 23.1). This structure variety, described by Renfrew as hearth ridge, is "simply a linear feature some 40cm long and rising about 15cm above the level of the floor" (Renfrew 1986, 187) (Fig. 23.11a-b).

In the LBA, only two structures with a clay border have been identified (Fig. 23.7, Table 23.1). At Kastanas V, at a semi-roofed space of "Nordhof" (layer 12) and in contact with a wall, a rectangular hearth (1.2x0.8m) was formed by a vertical border built of mudbricks (Hänsel 1989, 183, fig. 67, 73, 74, pl. 25.2) (Fig. 23.10b). The other feature comes from Thessaloniki Toumba IV and concerns a rectangular structure found in Building A (room A11, hearth 2, 1.1X0.8m, see Karadimou 1999, 157).

A.2.1.2 Structures with a clay floor

This subgroup consists of thermal features that disposed only a flat floor surface and had no border and is attested in very few BA sites (Fig. 23.7, Table 23.1).

In the EBA, borderless structures constitute 5% of the assemblage. Their shape is either circular, as in Agios Athanasios (E3, E10, E13 and E16) where diameters range from 0.63m to 1.1m and floors have a sherd sub-layer commonly founded in pits (Mavroidi 2012, 38-39, 55-56, 69, 76-77), or rectangular, as in Mesimeriani, where a 5cm thick clay layer was laid on the ground (Grammenos and Kotsos 2002, 63).

MBA Kastanas offers a single example, recovered in layer 22a and consisting of a clay floor 1.10X0.90m large (Aslanis 1985, 60, fig. 28) (Fig. 23.11c).

In the LBA, there are two examples (3%). The first was found in Platania (Boubousti) and it is described as a clay floor 0.04 m thick, circular in plan with a 1m diameter (Heurtley 1939, 40). The second is a circular clay floor, 1.4m in diameter, located in room 1 of the "Haupthaus" of Kastanas V (layer 12) (Hänsel 1989, 176, fig. 70).

A.2.1.3 Structures with a clay border and floor

This is the largest category of BA single room clay structures, comprising 89 items, 55%. Specifically, the EBA assemblage counts 54 examples (57%), the MBA one and the LBA 34 (55%) (Fig. 23.7, Table 23.1). This group presents great morphological diversity and, therefore, sub-types have been identified based on the plan form, the wall profile (straight or incurved) and the floor's construction technique (with or without substructure).

In the EBA period, 23 out of the 54 installations had some kind of substructure at their floor, whereas for 13 there is evidence that their walls were curved.[5] It is noteworthy that almost all of the structures with incurved rims had a U-shaped plan, except for three that were circular/oval. As far as the plan shapes are concerned the U-shaped is the most common with 27 examples, followed by the circular with 15, the oval with 5 and the semi-circular with one. In six cases poor preservation did not allow the identification of its form (Fig. 23.12). Of the 28 installations that exhibit a frontal entrance, the 26 belong to the U-shaped plan and the other two are circular and oval.

It becomes apparent that the prevalent type during the EBA is the U-shaped structure with a frontal opening for fuel loading and an inward curved border (Table 23.1, Fig. 23.13a).[6] At nine examples a sub-structure reinforced the clay floor.[7] The U-shaped features shown in the Fig. 23.14 diagram are medium-sized.

The structures with circular/oval plans are subdivided in two groups (Table 23.1). The first group includes three specimens equipped with a frontal opening (Fig. 23.13b). Due to this configuration, but also because of their overall construction details and dimensions, these features resemble the U-shaped structures and should be considered as a variant of this type. The second group contains 17 circular/oval features that were fully enclosed by a clay rim (Fig. 23.13c). In most cases there is no explicit information about the profile of the walls, since usually a few centimetres are preserved.[8] At 11 examples the floor possesses a sub-structure, with sherds being the most frequent construction material. At Agios Athanasios, the floor is either laid in a pit or on the ground.[9] The diameters of the structures range between 0.40 to 1.20m.

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5 Incurved rims are attested at Archontiko (Papadopoulou 2010, see appendix I for pk 5, 19, 26, 31, 36, 58), Mesimeriani (the oven of the "Burnt House" and one structure at level 5 in trench III, see Grammenos and Kotsos 2002, 62, 96), Sitagroi Va (oven 1 of the "Burnt House", see Renfrew 1986, 191) and Agios Mamas (two structures in "Haus 1" and one in "Haus 2", see Hänsel and Aslanis 2010, 67-68, 76-78). Here, we include also the so-called "potter's kiln" that Heurtley (1939, 5-7) reports from Agios Mamas. We believe that it was rather a cooking feature, since it bears a great resemblance to the EBA ovens revealed at the latest excavations at the settlement, e.g. the oven in the "Haus 3" (Hänsel and Aslanis 2010, 85).

6 The inclination was possible to be identified only in the well-preserved cases, where the walls were standing at a height of 0.20-0.30m.

7 This number is probably higher, since in some well-preserved features their floors were not tested with sections for sub-layers.

8 An exceptional example is reported at "Haus 2" Agios Mamas. It had a low rim, 0.10m thick, on which three circular depressions were formed (diam. 0.20m) for placing pots.

9 These variations correspond to the types A1 and B of Agios Athanasios (Mavroidi 2012, 75-77).

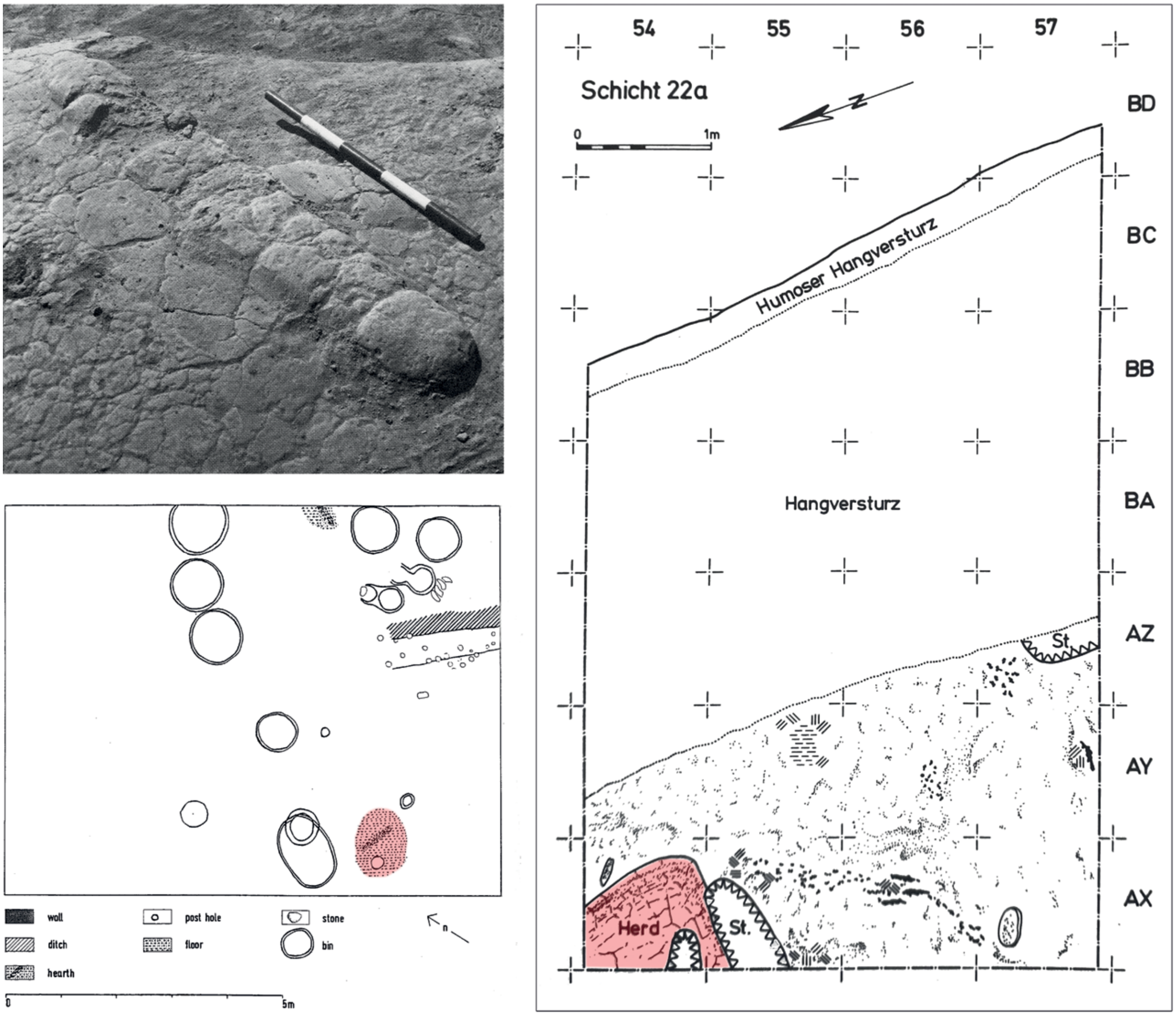

Fig. 23.11 Various types of clay structures. a type A.2.1.1 from EBA Sitagroi (Burnt house, after Renfrew 1986, plate XXIX); b from EBA Sitagroi (Bin Complex, after Renfrew 1986, figure 8.8); c type A.2.1.2 from MBA Kastanas (layer 22a, after Aslanis 1985, Abbildung 28).

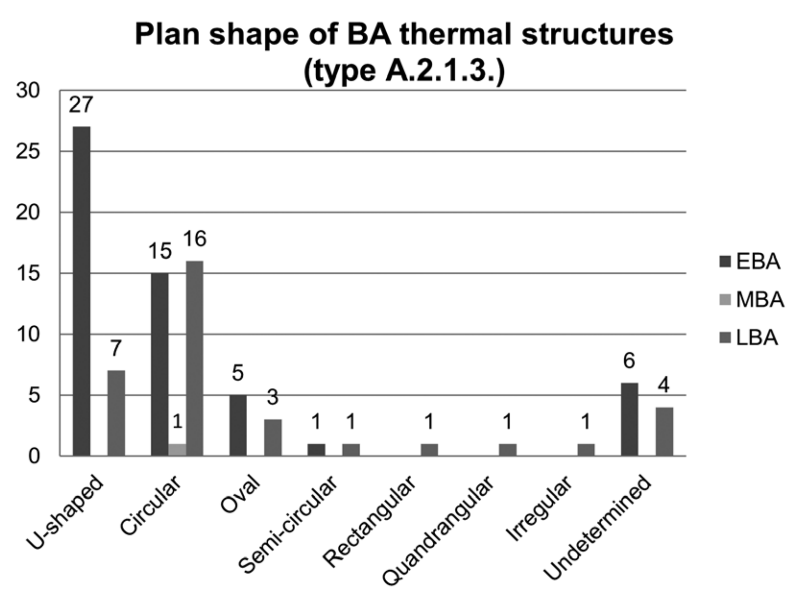

Fig. 23.12 Plan shape of the type A.2.1.3 structures in different Bronze Age periods.

Fig. 23.13 EBA clay structures of type A.2.1.3 with: a U-shape plan from Archontiko (pk 19); b oval plan and frontal opening from Archontiko (pk 26); c circular plan without opening from Agios Mamas (house 1, after Hänsel and Aslanis 2010, Abbildung 24).

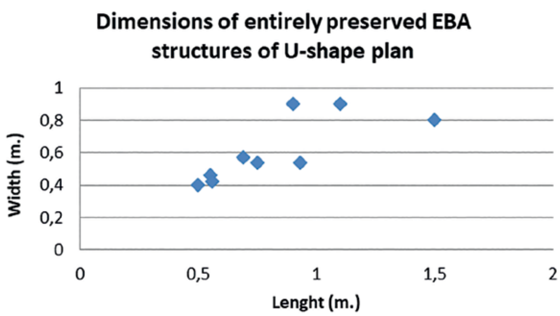

Fig. 23.14 Dimensions of entirely preserved EBA clay structures of U-shape plan.

Finally, a semi-circular structure with a clay floor is mentioned at Mesimeriani 6 (Grammenos and Kotsos 2002, 101).

The MBA period is represented by only one circular clay structure that comes from MH II Agios Mamas (layer 15, North complex, Raum 1) (Table 23.1). It consists of a clay floor 4cm thick that was enclosed by a low clay rim (Hänsel and Aslanis 2010, 141).

In the LBA, the clay structure assemblage is more limited than the EBA one (Fig. 23.7). Nine out of the 34 recorded examples have a floor sub-structure, whereas nine show evidence of curved walls.[10] The most common plan is the circular plan with 16 examples, followed by the U-shaped plan with seven, the oval with three, and finally the semi-circular, the rectangular and the quadrangular plan each with one example (Table 23.1, Fig. 23.12). A frontal opening is attested at 13 cases of which seven have a U-shaped plan, four are circular, one is oval and another rectangular.

The U-shaped type with frontal opening is also found in the LBA but in lower frequency (seven examples, see Table 23.1 and Fig. 23.15a-b). In two cases a sub-structure was found. Actually, at Angelochori II an elevated platform made of pebbles, sand, clay and mudbricks is reported in one example (Stefani 2010, 139-140 and fig. 4.2.13, 4.2.20). The size of these structures remains modest (Fig. 23.16).

The circular/oval plan structures are the most frequent LBA type. As with the EBA assemblage we distinguished two sub-groups (Table 23.1). The first one is represented by five structures with frontal opening and curved rims (Fig. 23.15b). Their diameters oscillate between 0.8 to 1.5m, while the oval example measures 1X0.8m. Two have a floor sub-structure. The second sub-group, without frontal opening, counts 13 installations. Little explicit information exists on the walls' form.[11] A pebble sub-structure is observed in two cases and a mixture of sherds and pebbles in another. For circular constructions, the diameters range from 0.5m to 1.3m, while for the oval structures, the length measures 0.9m and the width 0.8m.

Two rectangular/quadrangular structures are recorded at Kastanas V and Agios Mamas IV. The first one is 0.75 X 0.7m, while the second one 1.3 X 0.6m. Finally, one semi-circular structure is mentioned at advanced LBA Agios Mamas in layer 6 (Hänsel and Aslanis 2010, 218) (Table 23.1).

A.2.2. Complex structures

Clay structures with multiple compartments appear during the EBA. A two-room installation (type A.2.2.1), referred to here as the "Archontiko type", is attested at Archontiko III-IV,

10 Curved borders are attested at Platania/Boubousti 1-2 (Heurtley 1939, 40-43 and fig. 40.3, 41-43), Angelochori II (Stefani 2010, 139-141 and fig. 4.2.13, 4.2.20, 4.2.7), Kastanas V (Hänsel et al 1989, 156-157, 183 and fig. 55-57, Pl. 19.2, 20, 25.1), Toumba Thessaloniki (Andreou et al 2010, 360) and Angista (Koukouli-Chryssanthaki 1980, 56).

11 An original construction detail is reported from Boubousti 1 where part of a structure's border, preserved 0.70m high, consisted of a great pithos sherd. Also, fragments of "griddles" and bones were found on its floor (Heurtley 1939, 40-43 and fig. 41).

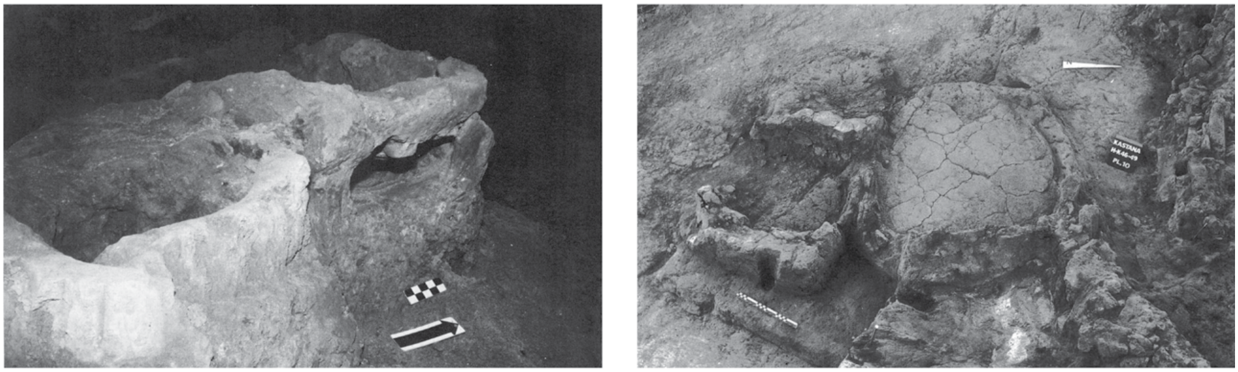

Fig. 23.15 LBA clay structures of type A.2.1.3 with: a U-shape plan from Anchialos (after Tiverios 1992, figure 1); b U-shape plan on the left and circular with entrance on the right from Kastanas (layer 13, Ofenhalle, after Hänsel 1989, Tafel 25.2).

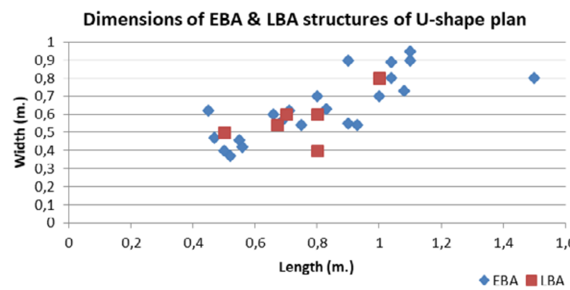

Fig. 23.16 Dimensions of EBA and LBA clay structures of U-shape plan.

Fig. 23.17 EBA complex thermal structures with two rooms (type A.2.2.1) from: a Archontiko (pk 25); b Sitagroi (Bin complex, feature C/D, after Renfrew 1986, plate XXI.1); c with multiple rooms (type A.2.2.2) from Archontiko (pk 55).

Sitagroi Va-b[12] and possibly at Dikili Tash IIIA (Darcque et al 2021) (Fig. 23.17a-b). The type is well known from eight examples at Archontiko III-IV, of which one is almost fully preserved. It is composed of two discrete communicating parts, a U-shaped firing chamber and a cylindrical baking space. A hole at the back of the firing chamber permits the hot airs of the combustion to enter the baking room, whereas another hole at the side of the latter facilitates the air flow or the release of some substance. In some structures, a small circular casing is attached just below the lateral hole. The mean dimensions of the Archontiko structures are 0.55 X 0.36m (Papaefthymiou et al 2007, 142-143, Papadopoulou 2010, 172-174).

Archontiko III offers us, finally, another peculiar type of thermal installation with multiple compartments (type A.2.2.2, Fig. 23.17c). It is oblong in plan (1.26mX 0.23-0.29m) and composed of two parallel, slightly converging clay walls. At one end the walls probably formed a small combustion space, while at the other they flanked a 0.10m diameter hole in the ground, surrounded at its rim with complete or fragmentary grinding stones that suffered burning. On top of the walls a small piece of clay floor suggests that the structure had also a second level (Papadopoulou et al 2007, 80, fig. 3; Papadopoulou and Maniatis 2013, 114-115).

12 After the Archontiko finds the oven 2 of the "Burnt House" and the features C/D and G/H of the "Bin complex" should be revised as two-room thermal structures (Renfrew 1986, 187, 191, fig. 88, pl. XXI.1, XXX-XXXI).

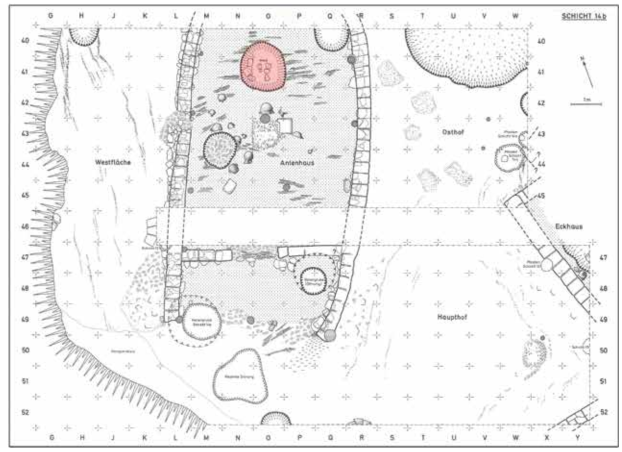

Fig. 23.18 Pit structures: a type B.1 from EBA Dikili Tash (6-023); b type B.3 from LBA Kastanas (after Hänsel 1989, Plan 12).

B. Pit structures

Fire pits seem not to be popular in the BA period. As their distinction from other kinds of pits, for e.g. rubbish pits, is not always easy, we believe that their original number was higher (Fig. 23.5, Table 23.1).

The EBA examples have been recovered at Sitagroi IV (Renfrew 1986, 177), Dikili Tash IIIA (Darcque et al 2021) and Molyvopyrgos 2 (Heurtley 1939, 14-15). In the first two sites the pits come from early EBA levels and they were circular in plan with their diameters ranging from 0.25 to 1.1m. The two shallow pits from Dikili Tash (6-023, 6-024) had their bottom rubified and contained ashes (type B1) (Fig. 23.18a), while the small pit from Sitagroi was coated with burnt clay (type B2). The pit from Molyvopyrgos is oval, bowl-shaped in profile and much larger, 2X1m and 0.40m deep (type B3). It was lined internally with stones set in clay and filled with a greasy deposit of black ash and charcoal, mixed with sherds and a few animal bones.

The only known LBA fire pit is recorded from the early LH IIIC "Antenhaus" of Kastanas IV (layer 14b) (Fig. 23.18b). A circular pit, 1.5m in diameter and filled with fine ashes, was found near the house's apse. It was flat bottomed and in the centre some stones were arranged in two parallel rows (Hänsel 1989, 125, pl. 15.1).

23.5 Discussion: reconstructing cooking techniques in Bronze Age northern Greece

The emerging picture resulting from the analysis of the thermal features of northern Greece reveals a great morphological variety across the BA, a fact that implies inter-site variability, imaginative technological inventions and diversity in cooking methods. Nonetheless, the prevalent construction material is clay, a trend probably inherited from the Neolithic and widely adopted across the region in the BA. Following the intriguing thought that the thermal structures are suggestive of diversified and intricate culinary traditions, we will engage then in an effort to reveal aspects of these traditions by associating each structure type with possible functional modes and cooking techniques.

Stone built installations are generally rare and their number gradually decreases from the Early to the Late Bronze Age. With measurements generally lacking, it is safe to say that their diameter ranges between 0.50-1m and specimens over 1m are rare. They appear in roofed and open spaces alike. Equally impressive is also the scarcity of the non-structured fire features. This fact may be partially a result of the incomplete or preliminary nature of the publication record and/or of the fragile character of the features' material remains.

Stone hearths and fire structures are both related to open fires and therefore, they can be linked to various procedures of direct or indirect cooking. In most sites stone hearths co-exist with clay structures. This pattern may suggest a diversified or complementary use. Open hearths serve also for heating and providing light when in indoor areas.

Underground fire structures are scarce. It is highly probable, however, that some pits with indications of burning and ashes or charcoal in their filling deposits, published as of undetermined use, were in fact destined for cooking. A dug-out structure may serve as a hearth or as an oven. In the first case, the fire burns in the pit and on its rim grills or spits can be placed for roasting. Alternatively, pots may be placed in the hearth on top of stones, stands or tripods. This was probably the case with the Final LBA hearth at the "Antenhaus" of Kastanas. The two parallel rows of lined up stones in the pit may have supported some of the cooking pots found nearby, such as handled deep pots and shallow pans (Hänsel 1989, 128, fig. 45; Hochstetter 1984, fig. 44-45).

In the case of the pit oven, the foodstuffs could have been rolled up in leafs, animal skins or other protective materials and then placed in the preheated pit and covered

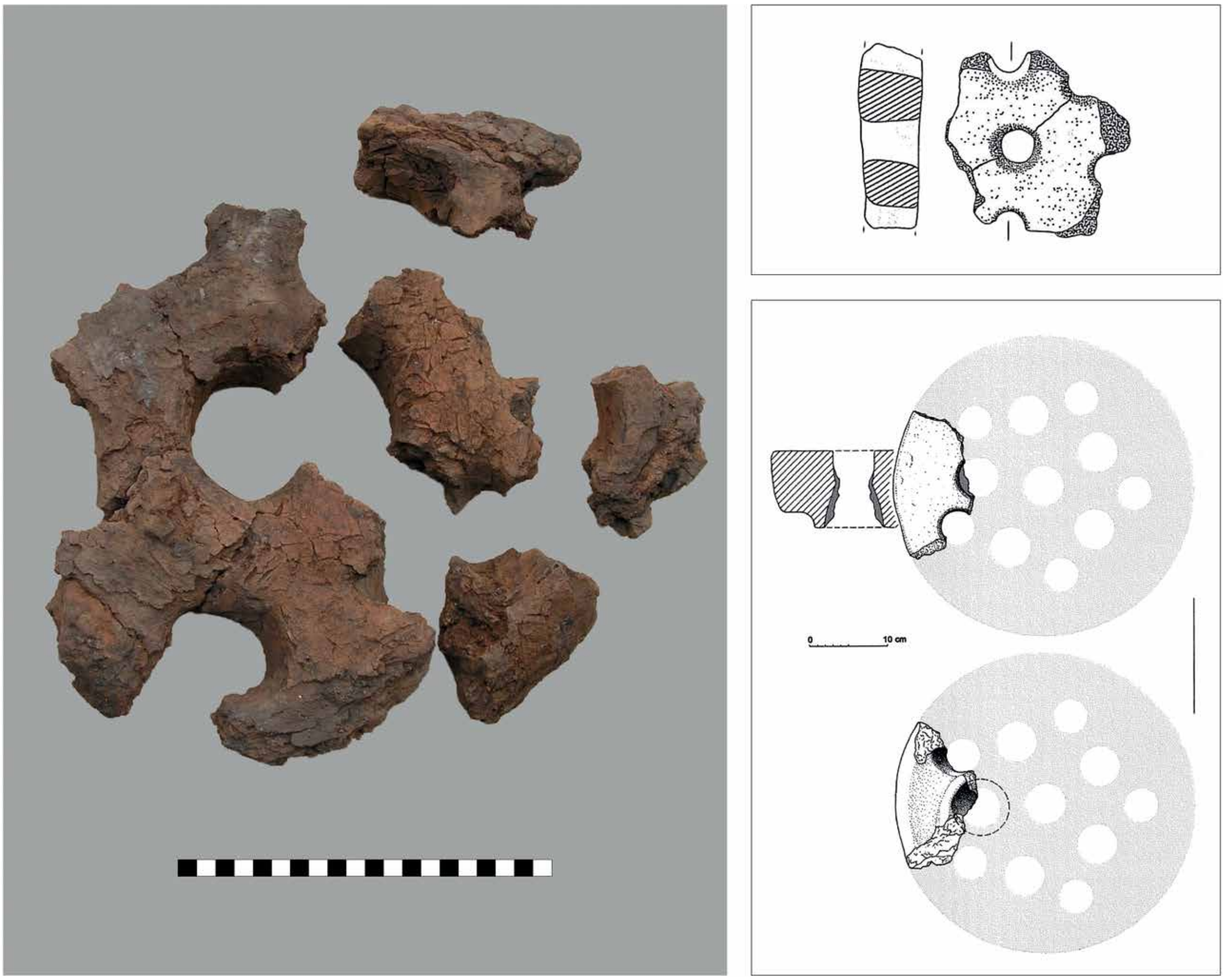

Fig. 23.19 Fragments of portable grills. a EBA Archontiko. The fragmented grill was found inside a U-shaped structure (pk 19); b Kastanas. The piece comes from a fill separating the EBA and MBA layers (after Aslanis 1985, Tafel 80.13); c EBA Agios Mamas. The grill fragment was retrieved from the debris of a U-shaped structure in house 3 (after Hänsel and Aslanis 2010, Abbildung 40).

with charcoals and earth. Sometimes stones are added in the oven in order to enhance its thermal efficiency (Papadopoulou and Prévost-Dermarkar 2007, 125). In this way the foods are slowly baked in a closed, humid environment, a technique known today in Greece as "kleftiko". The large, stone lined pit at EBA Molyvopyrgos was probably used likewise.

The clay thermal structures display more technical sophistication than their stone and pit counterparts. The first type (A.2.1.1) is solely composed of a clay border and is attested only at EBA Sitagroi and advanced LBA Kastanas. Technically, the border protects the fire zone from air drafts, diminishes accidents of fuel dispersal and directs the heat. The low linear rims of Sitagroi however are difficult to interpret, as they seem to be placed in the middle of the firing zone. At Kastanas the border is upright and rectangular in plan, forming a hearth that functioned next to the two U-shaped installations. Overall, rectangular shapes appear to be rather avoided in thermal structures. Although such shapes would have been appropriate for delimiting the combustion area, they would have been inconvenient for direct support of cooking vessels.

The second type (A.2.1.2) of single room clay features is characterized by the presence of a constructed floor that assures insulation from the ground and stores heat. A great disadvantage though is the absence of a protective surrounding screen that probably accounts for the limited dispersion of this type. Almost all examples, regardless of time period, are circular with the exception of one rectangular structure at EBA Mesimeriani.

The third type (A.2.1.3) of clay structure with 89 specimens is the most popular throughout the BA and technically the most efficient as it is equipped with a border

Fig. 23.20 Ethnographic examples of U-shaped hearths where cooking is conducted with pots or pans. a-b India, top row (©Wikimedia Commons, credit photo to: a Aurobinda Dutta; b Shivya at wts wikivoyage) c Ethiopia, bottom row, left (©Wikimedia Commons, credit photo to: Rod Waddington) d Mexico, bottom row, right (©Wikimedia Commons, credit photo to: Thelmadatter)

and an insulating floor. In the EBA the most frequent type is the U-shaped structure with the incurved walls and the frontal opening (Fig. 23.13a). The formation of the upper part of the walls is a critical technical matter, since it differentiates the function of the structure. A wide opening defines the feature as a hearth, while a small ventilation opening transforms it into an oven. Evidence that supports the first scenario comes from Archontiko IV where it was possible, with the help of reassembled clay fragments, to reconstruct an opening at the top of the clay structure (pilokataskevi) registered as pk19. Pieces of a portable grill that were found lying on the structure's floor confirm the presence of the opening and furthermore suggest that its diameter was around 0.30m (Papadopoulou 2010, 256 and fig. 7.2-7.4) (Fig. 23.19a). Fragments of similar clay grills are also reported at Kastanas II in layer 20 (Aslanis 1985, 129, Tafel 80.13 and 129.11), at EBA Agios Mamas (Hänsel and Aslanis 2010, 76-77) and at MBA Toumba Thessaloniki (Veropoulidou 2011, 351) (Fig. 23.19b-c). The limited size of the frontal entrance is another indication suggestive of an open and not domed setup. With an average width of 0.26m it is rather inconvenient for inserting foods and pots into the structure.[13]

The U-shaped hearths and their limited circular variant are ideal for supporting cooking vessels and hence, for the preparation of dishes, such as soups, gruels and stews. The vessel sits safely on the hearth's rims with large part of its body immersed in the hearth, while the cook can easily control the cooking temperature by adding or removing fuel from the frontal opening (Fig. 23.20). The shapes and dimensions of the BA cooking pots, as well as evidence of fire traces (see Dimoula et al this volume), comply with the morphology of this hearth type, supporting the suggested arrangement of a pot placed on a hearths' rim.

13 The average width was measured from 13 EBA structures from Agios Mamas and Archontiko. The height of the entrance is known only in three cases: EBA Agios Mamas (0.10m) and Archontiko (0.15m) and LBA Anchialos (0.17m) (Hänsel and Aslanis 2010, 67; Papadopoulou 2010, 214; Tiverios 1992, 357).

Cooking pots of the EBA and MBA are generally deep and open with a narrow base and handles or lugs below their rim. They are medium or large in size, with their heights varying between 16-46 cm and the rim diameters between 16-40 cm, occasionally exceeding these dimensions. In the course of the LBA cooking pots are characterized by more rounded body shapes and narrower mouths, whereas their bases are not exclusively flat, but frequently curved, requiring a sort of support to be placed over the fire. The pot dimensions again vary, 15-45cm for height and 15-50cm for rim diameter. Moreover, systematic study of fire traces on the cooking pots from Archontiko supports the hypothesis of their use over the upper opening of hearths (Deliopoulos et al 2011 for phases III-I; Dimoula et al 2022b for phase IV), corroborated by experimental results (Dimoula et al 2020). Finally, there is an example from Agios Mamas I, where a deep flat based cooking pot with handles and lugs, which contained some liquid food, was found fallen from the U-shaped hearth of House 1 at the site (Hänsel and Aslanis 2010, 73, fig. 44.3).

Several other cooking methods, such as grilling, roasting, parching or frying can be also achieved with the use of ancillary appliances, namely clay grills and pans, placed on the hearths we have identified. Shallow baking pans, or cooking dishes, of large diameter are encountered at many BA sites, while in the EBA they commonly have a series of perforations below the rim (see Dimoula et al 2022). Their bases are usually flat, especially of the pierced examples, but occasionally curved. Their average diameter could be estimated to 40cm and the height 5-10cm, but there are also much larger specimens e.g. a pan from Servia with d. over 60cm, (Wijnen et al 1979, 223, fig. 17). They commonly have fire traces on the rough exterior surface and very rarely in the smoothed interior. Such vessels could be placed among charcoals in hearths, or on stands or even over the rim of a hearth (Fig. 23.20b and d). The latter arrangement was probably attested at Boubousti 1, where Heurtley (1939, 40-43) claims to have found bones and fragments of "griddles" on the floor of a circular, high rimmed hearth.

The multi-functional U-shaped/oval hearths with entrance diminish in the LBA (Table 23.1). At the same time however, we notice that the circular structures increase in number (Fig. 23.12). Circular/elliptical or even rectangular fire installations, especially when their dimensions are large, demand some supporting device for the vessel in order to be at safe distance from the fire and to heat evenly. Stones are the simplest solution to the problem, as of course various types of portable stands. Interestingly, it is during the LBA period that elevated cooking pots are diffused in the region of Macedonia (see Dimoula et al this volume). Legged pots, such as tripods that are widely used in southern Greece, are only sporadically attested in the region, particularly in coastal sites e.g. in Pieria or Chalikidiki (see Dimoula et al 2022c). However, another type of vessel, the "pyraunos", with a stand attached to its body makes its appearance in the MBA and is adopted in almost all LBA sites (see Dimoula et al this volume, Figs 21.16a, 21.17, 21.19c). This type of cooker can be placed directly above charcoals or burning fires. In the LBA, its use spreads geographically, and at the same time hearths enclosed with vertical rims increase, a trend that probably suggests interlinked phenomena. The absence of pyrauna from EBA sites[14] is another clue in favor of this hypothesis, since the U-shaped/oval hearths with the upper opening served the vessel's support.

Although, the favorite EBA U-shaped hearth was never abandoned, LBA cooks turned to new fashions and enriched their kitchen gear. Why then adopt a new technical mode? The obvious advantage of "pyraunos" is that it allows cooking in any place, being portable and its deep body is ideal for liquid foods and stews, in various quantities, the largest ones reaching the capacity of 30 l. Visible organic residues at Early LBA "pyraunoi" at Archontiko are rare and randomly dispersed at their interior, a pattern that does not support boiling at least of fatty foods (Deliopoulos et al 2011, 227-228). In contrast, the "pyraunoi" from LBA Angelochori preserve visible organic residues in the interior, both the bottom and the walls. Their analysis has indicated the preparation of liquid dishes (Dimoula et al 2022b).

LBA developments in cooking facilities and pottery may be linked to the increasing variety of plant food ingredients consumed during that period in northern Greece. A new plant food ingredient, millet, related perhaps to specific culinary identities as it was a foreign cereal until the LBA in the region, might have required different ways of preparation and along with its introduction in the region, new food cooking techniques might have also been introduced. The hypothetical association of "pyraunos", a fusion cooking facility between a hearth and pot, may be linked to the arrival of millet in SE Europe, a hypothesis that needs to be tested on a large body of evidence with the support of residue analyses (for a discussion see Valamoti 2016).

An issue that arises from the data analysis and deserves further discussion is the difficulty of identifying vaulted ovens at the BA assemblages. Domed ovens are reported in the publications with the structure's layout, the entrance and the curved walls being the basic criteria for their identification. As we have stressed though, the same principles apply also for a particular BA hearth type. Since there is not yet an entirely preserved or at least a reconstructed dome from wall fragments, we lack solid evidence of fully covered structures. Preservation conditions are not in their favor, but this fact accounts for our difficulty in recognizing them rather than proves their complete absence from the archaeological record.

In all probability, ovens are hidden in the numerous unclassified examples and/or in the group of the U-shaped/

14 One "pyraunos" is reported by Aslanis (1985, Tafel 88.2) from EBA Vardaroftsa 4, but this is probably intrusive.

oval hearths with entrance. In the latter case, one has to seek for possible candidates in the few larger sized examples of the category that measure more than 1m in length or in the cases where a wooden frame was used for the construction of the walls. However, U-shaped structures are overall of modest size (their average maximal length is 0.72m and their width 0.64m)[15], providing thus a small baking space. Supposing were they closed by a dome, their baking chamber would be accessible by the narrow frontal entrance. Hence, baking seems inconvenient in these small structures, a hypothesis verified also experimentally with an oven model of this form (Papadopoulou 2010, 321-322). An alternative suggestion would be to interpret the U-shaped/oval structures as multifunctional devices, serving as both hearths and ovens with some minor adjustments. However, cooking experiments conducted on U-shaped hearths reconstructed according to the Archontiko finds have demonstrated that bread baking in their firing box by tightly closing the top and front opening was not successful (Papadopoulou 2010, 316-318, Papadopoulou 2022). Nevertheless, it is possible that other foods requiring less cooking time and/or lower temperatures might have been prepared, a hypothesis that needs to be researched experimentally in the future.

The EBA period is characterized by the presence of complex cooking structures (A.2.2). The two types (A.2.2.1 and A.2.2.2) that have been so far identified, despite their enigmatic function[16], suggest that EBA cooks developed sophisticated constructions for special thermal processing purposes. As we have seen, this tradition appears to have fallen out of use by the LBA communities of northern Greece.

A final issue of discussion is the spatial distribution of the various structure types in the settlements of BA Macedonia. The organization of these features in settlement settings, the search for local trends or the ways the different structure types co-exist at each site are matters that deserve a separate study. So, in the present paper only some general observations will be made. First, it appears that some sites exhibit high numbers of structures, as for instance Archontiko (26), Dikili Tash (19) and Sitagroi (15) in the EBA and Toumba (21) and Kastanas (19) in the LBA (Fig. 23.4). This first glance view needs to be checked in the future by considering factors, such as preservation conditions, the extent of the excavated surfaces, the nature of the deposits and the spaces. Secondly, most sites, both EBA and LBA, show structure variability on the intra-settlement level. This phenomenon is depicted in Tables 23.2-4 which list the different types encountered at each site. Thus, an interesting issue of further inquiry is the spatial relationships and combinations of these different types as well as the specific settings where they were constructed. Lastly, any patterns observed as regards the distribution of cooking structures in habitation settings should be interpreted with caution. In the past, the placement of Bronze Age cooking installations in roofed domestic spaces was considered as an indication of a more "introvert" household engaged in social antagonisms and expressing rupture with reciprocity ties that were thought to be prevalent in Neolithic times (Halstead 1999). In the EBA, domestic settings are characterized by a higher frequency and diversity of thermal structures. At some tell sites, they are found concentrated inside domestic spaces (e.g. Archontiko, Mesimeriani, Agios Mamas and Sitagroi Va), whereas in other cases they are present at both indoor or outdoor settings (Servia, Agios Athanasios, Limenaria). Therefore, spatial patterns of cooking installations need not be generalized, as they are linked to various parameters, such as, for example, the type and temporality of the cooking activity and the overall equipment it involves, the settlement type and its architectural tradition, the extent and nature of the excavated deposits. Future research should concentrate on these issues in order to better understand domestic cooking activities in Bronze Age Macedonia and their social implications.

23.6 Conclusions

To summarize, we would like to highlight certain observations that emerged from the study of the thermal features in BA northern Greece. First of all, it should be stressed that both EBA and LBA communities share the same technological asset in the construction modes and in the morphology of the thermal structures. Hence, the basic EBA types, the U-shaped/oval structures with entrance and the circular/oval structures with vertical border survive well into the LBA. A noticeable exception though is the disappearance of the two-room features in the LBA and also the occurrence, albeit rare, of the rectangular structures. The construction techniques remain more or less the same, despite the occasional use of mudbricks in the LBA. With clay structures taking the lead, other types of cooking installations, such as the stone fireplaces or the fire pits were used sporadically in both periods.

The traced differences between the EBA and LBA repertoire of thermal structures are indicative of diverse preferences in structure types rather than of discontinuities and technological breaks. So, in the LBA circular/oval structures with border sidestep the U-shaped/oval structures with entrance and become more fashionable. Another element that is certainly impressive is the higher number of cooking installations in the EBA over the LBA settlements, an observation that needs further evaluation in the future under the light of parameters, such as the excavated size of the sites, the nature of their deposits and, of course, the

15 The measurements include also the wall thickness and were collected from 29 examples.

16 For suggestions about the operation of these structures, see Papaefthymiou et al 2007, 142-143; Papadopoulou and Maniatis 2013, 121.

changes in the spatial organization of habitation as large residential-blocks make their appearance in the LBA. Nonetheless, the data reveal differences of scale between EBA and LBA thermal structures and diverse choices, which appear to be linked with other parallel changes in the kitchen field, especially in the ceramic repertoire. We believe that in the LBA the wide diffusion of "pyraunos", namely a portable hearth, is possibly accountable for the lower frequency of fire installations in this period as well as for the more restricted use of the U-shaped structures. A question for future research, in order to better understand this trend, would be to study the relationships of the portable "pyraunoi" with the fire installations at settlement spaces[17]. Even more puzzling are the reasons that triggered this cooking fashion. One should turn for plausible answers to the wider changes taking place, with the passage from the EBA to the LBA, in the dietary regime (e.g. the appearance of broomcorn millet, decrease in game, more intensive crop production) (Nitsch et al 2017), in food storage management (supra-household hording) as well as in the social realm (formation of large co-residential groups).

Cooking methods in both periods were diverse. Even on the settlement level we observed the parallel use of various forms of thermal structures. Boiling, simmering, stewing and steaming were achieved in cooking vessels placed directly or indirectly on the various hearth types and open fires or in "pyraunoi". Grilling with the help of clay grills, wooden spits or sticks was another option as well as the low thermal treatment for specialized food processing, perhaps smoking (Papadopoulou 2022) or brewing (Valamoti 2018) that was practiced in the "Archontiko type" structures. The evidence for baking is more complicated, as baking ovens are difficult to identify. Some large U-shape/oval features, however, were probably used for that purpose. Wide rimmed pans are another possible means for baking.

The present research reveals the dynamic of thermal installations in studying cooking technology. At the same time it stresses the need to approach past cuisines as an ensemble through combined researches. Certainly, a lot of questions still remain to be explored, as for instance the organization of cooking in EBA and LBA domestic spaces, the combinations of different fire structures at the intra-site level, the relationship between kitchen ingredients and cooking technologies or the social contexts of cooking. Undeniably, there is a lot of work to be done in the field and a lot of new things to be learnt. We believe that our study will contribute towards future, integrated investigations of Bronze Age culinary practices in northern Greece and beyond.

17 E.g. the study of MBA-LBA cooking pottery from the region of Pieria has shown that in these sites "*pyraunoi*" were generally found in exterior spaces (Dimoula et al 2022c).

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Chapter 24

Clay cooking ware and kitchen equipment in the ancient Greek household

Eleni Manakidou

Abstract

A considerable amount of archaeological material is linked with food-preparation and the culinary activities that took place in domestic and public space in the ancient Greek world. A certain place or room intended exclusively for cooking and keeping all necessary equipment cannot always be recognized in ancient Greek houses. The occasional ambiguity of the items referring to ancient Greek "kitchen ware" is often clarified through excavation contexts which include a combination of finds (structures, vessels, and organic remains) and with the help of written and iconographic sources. Different shapes of cooking pottery (*chytra*, *kakkabe*, *lopas*, *teganon*) testify the variety of recipes that corresponded to different culinary preferences depending on specific regions and periods. Other implements, mostly portable such as ovens, braziers, and grills, are connected with the processes of cooking, roasting and baking. Some devices like mortars in several forms and sizes with their grinders relate to cereal- and food-processing for the mixing of pulses and sauces; some others like trays or basins have been used for dough kneading. The preparation and consumption of bread and pastries played a primary role in ancient Greek diet. Finally, the dissemination of various cooking pots in several areas is of importance not only for their functional value and technological superiority but perhaps also for the adoption of certain recipes and the change of eating habits.

Keywords: *cooking pots, ovens, braziers, mortars, culinary practices, Aegina, Athens, Corinth, East Greece*

24.1 Cooking spaces and contexts: some general remarks

The existence of a separate kitchen-room used exclusively for food-preparation and for keeping all necessary cooking ware and equipment is an anachronism when we look at the ancient Greek *oikos* (*οἶκος*), both as a residence and as a household. The main reason is the lack of "domesticity" in its modern sense in the context of the ancient Greek family. Another practical reason is that limited means for long-term preservation of cooked food forced people to cook more often -even several times per day- and to eat simple, light meals at home. Food-preparing was an all-day activity, but the effort and the ingredients spent for cooked food were kept to a minimum amount according to household economy and organization (on material and other aspects of these complex matters, see Ault 2007, 2015; Ault and Nevett 2005; Nevett 2010; Westgate 2015).

Communal and ritual feasts offered the most suitable occasions for rich meals with meat consumption. Such public gatherings took place in indoor and outdoor areas already

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from the Early Iron Age, enhancing the commensality and the collective spirit among the male members of the community. This is documented by the finds from many sanctuaries and public buildings that include cooking, serving and drinking pottery in large quantities (see Rotroff and Oakley 1992; also the contributions in van den Eijden et al 2018). The best evidence for the official organization of such communal meals is provided by the diachronic existence of the *prytaneion*, an independent building in the Agora of many Greek city-states, where the official hearth of the city was located and various forms of public dining were held among fellow citizens and foreign guests. The long-lasting tradition of this institution is proven by the mentioning of such buildings in the ancient sources since the Archaic period (see for example Miller 1978; Schmalz 2006) and special studies have examined the meaning of the communal and domestic hearth in the context of ancient Greek society (see Foxhall 2007, 234; Tsakirgis 2007, 230). Similar feasts occurred during the local or panhellenic festivals, when considerable groups of people gathered in sanctuaries and large amounts of foods (including meat) and drinks were consumed. The specific rooms where these celebrations took place have been excavated in many sites and they have been identified as dining halls, the so-called *hestiatoria* (*ἑστιατόριον*, *-α*). Women had also sometimes the opportunity for sumptuous group meals with their peers as evidenced by written sources and iconographic representations.

In an ancient Greek house, the area intended for cooking and storing some of the household's ware and other culinary equipment is sometimes called *optanion* (*ὀπτάνιον*). This term is found more often among Attic Comic poets (Aristophanes *Knights* 1033, and *Peace* 891; Alexis *Pannychis* 2.43; Philemon *Pareision* 2; cf. *IG II2* 1672 and 2499) but it does not seem to be so prevalent until the Classical period. An increasing specialization in cooking methods, food professionals and consequently in specialized kitchen areas became more apparent in the archaeological and literary record from the 4th c BC onwards revealing a higher degree of social differentiation and wealth display in the Late Classical and Hellenistic periods.

Nowadays, a lot of food-related activities are expected to take place in a single room of the house, but this was probably not the case in antiquity. The modern notion of a kitchen, i.e. a room used for food processing and cooking, cannot always be applied in ancient Greece as food-preparation varied depending on seasonal and other conditions (Sparkes 1962, 129, 132; Foxhall 2007, 240-242; Nevett 2010, 18, 41, 49; Ault 2015, 206, 208). In general, excavations often do not provide sufficient evidence for an exclusive use of a single room as a kitchen, but rather the opposite. Individual rooms or room-complexes often display a multifunctional character, varying according to size and plan, but also according to the placement and type of items found inside them, suggesting that they could occasionally have functioned as kitchens, especially when they had a fixed hearth and an installed flue (Chatzidakis 2000, 117-118; Cahill 2002, 80-81, 153-157; Tsakirgis 2007, 226-228; Haggis et al 2011, 436, 479-481). On the other hand, the central courtyard of the house played an important role in domestic life, and a lot of daily activities that involved all members of the household were accomplished in this area. In particular, in terms of food-preparation, several categories of archaeological material (structures, artefacts, botanical and zoological remains, combustion residues) show that raw ingredients could be processed there, meals could also be cooked and eaten in this open yet protected space, and even a festive gathering or the welcoming of a guest could be held there, weather permitting.

24.2 Clay cooking equipment: artefacts and representations

Thanks to systematic excavations both in urban and rural residential areas in many regions of the ancient Greek world, we can obtain a good picture of the arrangement and furnishing of private dwellings. Increasingly, the archaeological research is paying close attention to the evaluation and study of all finds, something that did not happen in the past until recently. Most of the excavated houses belong to the Classical and Hellenistic periods but, despite differences in size and plan, they have a lot in common and they provide enough material for the study of cooking vessels and culinary ware. Adequate information offers the relevant material found as well in many city-houses, to mention only the better-examined cases of Olynthus in Chalcidice and Halieis in Argolis, as in farmhouses like the "Dema House" and the "Vari House" in the countryside of Attica (Ault and Nevett 1999, 46-53; Cahill 2002; Foxhall 2007, 235-240; Jones et al 1962, 1973). Houses with various plans and sizes have been recovered in the residential areas of other big or small cities (for example Athens, Eretria, Pella, Thasos, Kolophon, Priene, Delos, Halos, Azoria) and they have been studied one way or another. As most of these objects were portable and of medium size, they are light-weight and could be easily transported from one place to another. Regarding their finding spot ("final deposition") in each case we must keep in mind that they may have been moved from their original place or that they may not have had a permanent place in the house at all. Many types of these cooking pots and devices are also known from their depictions on vases and figurines that illustrate scenes of everyday life (Fig. 24.1) (for examples see Pisani 2003; Sparkes 1962, 1965, 1975; Villing 2009, 322-328); these representations can be very helpful for understanding the use and dissemination of the real artefacts, as well as the various cooking practices.

Fig. 24.1 Terracotta figurines. a Woman baking, London British Museum Inv. Nr. 1966,0328.22, from Boeotia, ca 500 BC; b Woman grinding, London British Museum Inv. Nr. GR 1856.9-2.63 from Kamiros, ca 450 BC (©Trustees of the British Museum).

The verbs that describe the two main ways of cooking in Ancient Greek are "*ὀπτάω*" (roast, cook with dry heat and without water) and "*ἕψω*" (boil, stew), both referring to a considerable number of raw materials and cooking devices. Certain types of food could be either boiled or roasted (Plato *Euthydemos* 301C: [τὰ σμικρὰ κρέα] κατακόψαντα ἕψειν καὶ ὀπτᾶν). The main ingredients for most of the dishes served at the daily table had little variety and originated from plants. Many foods could be eaten raw and without special preparation.

The key difference between the two kinds of meals that ancient Greeks ate involves on the one hand the plain consumption of *sitos* (*σῖτος*: bread) and *maza* (*μᾶζα*: dough, pastry) and on the other, the complicate preparation of *opson* (*ὄψον*: side dish, delicacy) (Sparkes 1962, 123, 128; Rotroff and Oakley 1992, 48-49; Villing and Pemberton 2010, 613-614). The verb "ὀψοφαγέω" (Aristophanes *The Clouds* 983) became synonym for luxurious, gourmet diet and ravenous appetite. In modern Greek diet there is the equivalent term "προσφάι" that means all kind of plain food eaten as supplement with bread, see Kyriakopoulos 2015, 253-254). *Sitos* and *maza* were the basic and most important parts of ancient Greek diet, a role maintained until today in Greece and the wider Eastern Mediterranean area. In addition to bread and pies, people ate vegetables, fruits, eggs and cheese in various combinations. *Opson* is more demanding, time-consuming, and expensive. It reveals the preference for elaborate plates, cooked with special ingredients and spicy sauces (*τρίμματα*, *ἀρτύματα*, *καρυκεύματα*). A famous one was the *myttotos* (μυττωτός) that went well with fish dishes (Villing and Pemberton 2010, 615-616).

Turning to kitchen ware, the *chytra* (*χύτρα*) is the prevailing cooking pot with a rather standard shape, regardless of many size- and fabric-variations that occurred over different geographical areas and a longtime-span of production. The basic shape of this pot remained more-or-less unchanged over the centuries because it was very practical and functional (Sparkes and Talcott 1970, 224-226; Bats 1988, 45-46; Chatzidakis 2000 125-126; Aydemir 2005, 87-89; Knigge 2005, 151 nr. 311-312, 178 nr. 490-492, 200 nr. 688-689, 207 nr. 767-769, 221 nr. 900-904; Trapichler 2005, 70; Rotroff 2006, 165-171; Haggis et al 2011, 467-468; Klebinder-Gauss 2012, 182-184; Quercia 2015, 205-207, 210; this particular shape appears also in ancient Greek proverbs denoting futile effort: [Aristophanes *Assemblywomen* 845; Plato *Hippias Major* 290D]). Only the introduction of new raw materials, more complex recipes and differentiated culinary preferences led to the invention of other cooking vessels, and even then, they coexisted with the traditional deep-cooking pots. The significance of the specialized manufacture for cooking pots is attested by the use of a specific name for the *chytra*-maker (*χυτρεύς*, *χυτροπλάθος*), given to the

Fig. 24.2 *Chytra-Kakkabe*, Athens Agora Museum Inv. Nr. P 8792, context 420-400 BC (©American School of Classical Studies at Athens: Agora Excavations).

potters that produced them, although sometimes it applied also to potters of other types of clay vessels. By analogy in Modern Greek the term "*tsoukalas*" (*τσουκαλάς*) starting from the potter of cooking pots (from *τσούκα*, *τσουκάλι*) ended up meaning the potter in general (see Kyriakopoulos 2015, 260). From the same root also comes the name "*tsoukalario*" (*τσουκαλαριό*) that indicates the traditional pottery workshop or the place where many pot-sherds and broken vessels are accumulated. Interesting to note is also the conservatism in the nomenclature of cooking pots through the centuries in the different stages of the Greek language and therefore in the formation of the Greek culinary character.

Chytrai usually have one vertical strap handle, less frequently two; they can be lidded or lidless. Their body is globular, with more or less symmetrical shape, which sometimes appears baggy, and without a shaped base. They have a plain, straight, or outturned rim and a narrow neck with a continuous profile with the body. Two-handled *chytrai* (with handles sometimes extending beyond the rim) have generally wider mouth with profiled rim and broader body. These deep containers were used for the preparation of soups, broths, and porridges, containing vegetables, legumes, cereals, and sometimes meat (or more frequently, bones with marrow), but also for boiling water for various other uses (for example bathing, and cleaning).

The *kakkabos* or *kakkabe* (*κάκκαβος*, *κακκάβη*) is a lidded version of the *chytra* with quite a deep body (Fig. 24.2) and sometimes a three-legged stand attached to its bottom. In some areas, as in Magna Grecia (South Italy, Sicily), the *kakkabos* became gradually flatter and broader with a stepped, out-turned rim and a cover (Bats 1988, 46-48; Knigge 2005, 200 nr. 691-692, 208 nr. 770, 221 nr. 903; Trapichler 2005, 70-74; Rotroff 2006, 172-178; Quercia 2015, 207). This pot served especially for the cooking of fish soups, as indicated by its name and the homonymous recipe that survives until today. The Greek "kakkavia" is the equivalent of other similar Mediterranean fishermen's soups, such as the Italian "cacciucco", the French "bouillabaisse", the Spanish "zarzuela" and the Portuguese "caldeirada".

Another cooking pot, the *lopas* (*λοπάς*), is a popular open-vessel used as a stewpot (casserole). It has a wide, stepped rim that receives a vaulted lid; a short vertical neck; a flattened body that has a curved profile with rounded bottom; and two horizontal, round handles raised to the rim (Fig. 24.3). Its prevalence from the late 5th c BC onwards confirms a certain change of taste and cooking habits or rather implies the emergence of new recipes. The spacious capacity of this shallow pot allowed the slow braising of stews and ragouts with various types of fish as their main ingredient (Sparkes and Talcott 1970, 227-228; Bats 1988, 48-50; Chatzidakis 2000, 126-127; Knigge 2005, 140 nr. 229, 152 nr. 317, 189 nr. 584-587, 200 nr. 693-694, 221 nr. 906-907; Rotroff 2006, 178-186; Klebinder-Gauss 2012, 185-186; Quercia 2015, 207, 209; Mistireki 2019). The archaeometrical analysis with gas chromatography of samples taken from lopades discovered traces of fish and vegetables (Mistireki 2019, 37-38). It is worth noting that this cooking vessel became popular also outside the Greek world, as numerous finds of lopades in the Western Mediterranean (Etruria, South Italy and Sicily, South Gaul) and the Black Sea attest.

Occasionally, the *kakkabos* and the *lopas* had a tube-spout for the exit of steam from the covered vessel, like modern pressure cookers (Sparkes and Talcott 1970, 225,

Fig. 24.3 *Lopas*, Athens Agora Museum Inv. Nr. P 16156, last quarter of 5th c BC (©American School of Classical Studies at Athens: Agora Excavations).

Fig. 24.4 Terracotta figurine of a woman cooking with *chytra* on props, Berlin Altes Museum, Antikensammlung Inv. Nr. 31464, from Boeotia, 6th c BC (©SMB/ Antikensammlung, Foto: Johannes Kramer).

Fig. 24.5 Kitchen ware found in the Athenian Agora. a *Chytra* P 25007 on Stand-*Pyraunos* P 25008, 570-540 BC; b *Lopas* P 2360 with lid P 1008 on Brazier P 19598; c Tripod Casserole P 13710, 470-460 BC (©American School of Classical Studies at Athens, Agora Excavations).

Fig. 24.6 a, b Terracotta figurine of a woman seated in front of an oven with bread rolls in it, Berlin Altes Museum, Antikensammlung Inv. Nr. 31464, from Boeotia, early 5th c BC (©SMB/Antikensammlung, photo: Johannes Kramer).

227; Knigge 2005, 151 nr. 309-310; Klebinder-Gauss 2012, 184-185). They were preferred for cooking dishes that steam in their own brew and the predominance of this kind of cooking pots shows a change in eating habits during the Classical and Hellenistic periods. The popularity and further dissemination of both shapes and their many variations all over the Mediterranean world are indicative of trade connections and a certain acculturation among peoples that lived in these areas, also in terms of culinary habits. Miniature *chytrai* (*chytridia*, *χυτρίδια*) and *lopades* (*lopadia*, *λοπάδια*) were also common for special uses as shown from their excavation contexts (Rotroff 2013, 3, 5, 17-23). One can think also of the third day of Anthesteria, called *Chytroi*, with edible offerings for the dead brought into small *chytrai*).

Close- and open-shape cooking pots can be mounted on two high trumpet-like props called *lasana* (*λάσανον* -α) or *chytropodes* (*χυτρόπους -οδες*) (Morris 1985; Aydemir 2005, 89-90; Claquin 2015, 484). These peculiar objects have a cylindrical body with discoid ends and a vertical handle; they are sometimes open at top and bottom or have vent holes on the body and they functioned as supports allowing better circulation of the heat from the open fire burning under the pot (Fig. 24.4). There were also other supports of semi-circular (horseshoe-like) or cylindrical shape for placing the pots over the fire.

Considering the above-mentioned features related to the question of functionality and mobility of the ancient Greek kitchen, it is understandable why almost all cooking appliances were portable and easy to handle (Fig. 24.5). Food can be cooked under different heating

Fig. 24.7 Brazier, Athens Agora Museum Inv. Nr. P 17989, 3rd c BC (©American School of Classical Studies at Athens, Agora Excavations).

conditions, attended with a limited variety of devices (for experimental heating on cooking vessels of globular and cylindrical shape, but without indicating the type of the heating source, see Hein et al 2015). Ovens (*ἰπνός*) with standardized forms and of medium size were necessary for baking bread and pastries and are often shown in cookery scenes of Late Archaic and Classical vases and terracottas (Fig. 24.6).

A brazier, often called *pyraunon* or *eschara* (*πύραυνον*, *ἐσχάρα*), fueled by charcoal, kindling wood or ember was used for boiling, roasting and broiling (Sparkes 1962, 128-129; Sparkes and Talcott 1970, 232-233, 234-235; Knigge 2005, 158 nr. 375, 201 nr. 697; Rotroff 2006, 199-222; Ault 2015, 209; Claquin 2015, 484-487. In modern Greece, similar ways of traditional cooking still exist with the use of braziers [πυροστιά, φουφού, μαγκάλι]). These portable devices allowed cooking to take place in different areas of the house without the need of a fixed hearth. Tripodal braziers are known from the Early Iron Age. In certain areas compound cooking pots and braziers with uncommon formats have been found, as in Iron Age settlements of Central Macedonia (see Carrington-Smith 2000, 219-223; Savvopoulou 2014). Cylindrical braziers are documented from the Classical period; they were partially open and pierced. Braziers became more elaborate during the Hellenistic period, largely widespread in the Eastern Mediterranean; they consisted of two parts (a hollow stand and a hemispherical fire bowl) and combined practical with decorative elements (Fig. 24.7). Other portable *escharai* were circular or rectangular with a shallow stand and a deep heavy bowl, and occasional protrusions on the rim for putting roasting spits (skewers). A portable oven or a cooking bell (*γαστρόπτης*, *πνιγεύς*) could be placed over an *eschara* when a small amount of food had to be cooked. Portable clay and metal grills of circular or rectangular shape (Fig. 24.8) were also available for small portions of grilled fish, meat, and vegetables (Sparkes and Talcott 1970, 233-234; Chatzidakis 2000, 128; Claquin 2015, 487-488 ["fish-shaped" grills]). A special and not so common device was the barrel stove (*κρίβανος*) probably for baking pita-bread (Fig. 24.9) that resembles the modern ovens of similar shape for flatbread that are very common in North Africa, the Middle East and Central Asia under a variety of names with slight differences from each other (taboon,

Fig. 24.8 a, b Terracotta figurine of a man seated in front of a grill blowing the fire with a mat, Berlin Altes Museum, Antikensammlung Inv. Nr. TC 6674, from Tanagra, early 5th c BC (©SMB/Antikensammlung, photo: Johannes Kramer).

Fig. 24.9 Terracotta figurine of a woman holding a pita-bread in order to put it into a barrel stove, from Akanthos (Ierissos), late 6th – early 5th c BC, Polygyros Archaeological Museum I.74.345b (©Ephorate of Antiquities of Halkidiki and Mountain Athos).

tabouna, tann[o]ur, tandoor, tandur, tandir) (Sparkes 1962, 130, 1981; Sparkes and Talcott 1970, 233; Pisani 2003, 17-18; Rotroff 2006, 222).

Various basins, sometimes mounted on high stands, and trays existed for kneading (*κάρδοπος*, *μάκτρα*), as it is shown in vase depictions and terracotta figurines with the preparation of bread and other baked goods (Sparkes 1962, 126-127; Pisani 2003, 10-13; Cahill 2002, 167-168). The popularity of these scenes together with those of "bakers", men and women, in front of ovens reveals the importance of bread as a staple food for most people in the ancient Greek world. Parching pans and griddles of different shapes, sizes, and depth are found in many contexts and they were suitable for roasts, baked vegetables, flat breads, and pastries. They are usually hand-made, and they often have traces of burning (soot, ashes) and wear (see Carrington-Smith 2000, 220, 224-227; Manakidou 2014, 118). Frying pans (*τάγηνον*, *φρύγετρον*) are usually flat-bottomed with one or two small handles used for sautés, pancakes, and egg preparations (Sparkes and Talcott 1970, 228; Bats 1988, 50; Knigge 2005, 189 nr. 588-589; Rotroff 2006, 186-195). Of course, there are also other auxiliary items such as strainers (*ἠθμός*), graters (*κνῆστις*), sieves (*σείσων*), funnels (*χώνη*), ladles (*ἀρυτήρ*, *κύαθος*), jugs, lekanai and storage bins made of various materials, also metallic items (such as knives, spits) that complemented the kitchen equipment.

The ceramic mortar (*θυεία*, *ἴγδις* / *ἰγδίον*, mortarium) was a robust household device for grinding, crushing, mashing and mixing food ingredients (seeds, vegetables, herbs, fruits, and even cheese) in order to prepare various kinds of sauces, gruels and porridges (Fig. 24.10) (for its various forms and uses, see Sparkes 1962, 125; Sparkes and Talcott 1970, 221-223; Rotroff 2006, 99-103; Villing 2009; Villing and Pemberton 2010, 602-620). The main shape of a mortar is that of a shallow bowl (conical or hemispherical) with a thick profiled rim and a flat base, with or without a spout. There are variations in size, fabric, and manufacture technique (wheelmade or moldmade), depending on the place and period of production. Regardless of these minor differences, all mortars were heavily used in daily food-preparation. This explains the traces of abrasion on the interior and the bottom surfaces on many examples. Signs of repairs (holes and lead-strips) prove that they were costly items and perhaps not so easily to be replaced (Fig. 24.11). Their coarse fabric (gritty clay, tile clay with mudstone) was enriched with inclusions and surface grit to enhance the durability of this valuable implement. In the Classical and Hellenistic periods mortars were also made of stone or marble (Chatzidakis 2000, 123; Korkut 2002). The grinder or pestle (*δοῖδυξ*, *ἀλετρίβανος*)

Fig. 24.10 Terracotta figurine of a donkey carrying a mortar with pestle, grater, round cheese, and bundle of garlic on it, London British Museum Inv. Nr. 1873,0820.576, ca 350 BC (©Trustees of the British Museum).

Fig. 24.11 Mended Cypro-Phoenician mortar from the settlement at Karabournaki, Excavation Magazine Inv. Nr. K97.981a-b + K97.1123a-e + K97.1124, early 6th c BC (©Photo Archive of the Aristotle University Excavation Karabournaki).

used with clay mortars had different shapes (discoid, elongate, mushroom- or finger-shaped); it was made mostly of wood, exceptionally of clay or later of stone and marble, therefore leaving in most cases no traces in the archaeological record.

It is noteworthy that mortars have been found not only in domestic and industrial contexts but also in sanctuaries as votives and as ritual objects. The sanctuaries are scattered throughout the ancient Greek world, such as those of Aphrodite at Miletos, Artemis at Ephesos, Hera at Samos, Apollo at Naukratis, Demeter and Asklepios at Corinth (see Villing 2006; Villing and Pemberton 2010, 621-623). Another interesting fact is the dissemination of Archaic and Classical mortars beyond the area of their manufacture to more distant destinations. For example, Cypro-Phoenician (Levantine) terracotta mortars with their very distinct fabric and shape have been found in many sites in the Eastern Mediterranean and the Black Sea, even in Etruria, during the Archaic period (Bellelli and Botto 2002; Villing 2006; Spataro and Villing 2009; Zukerman and Ben-Shlomo 2011; Manakidou 2014, 119-120). Corinthian coarse-ware mortars became very popular from the Classical period and later on and they were exported in many regions together with terracotta basins (*louteria*, λουτήρια, *perirrhanteria*, περιρραντήρια) and architectural pieces from the same workshop (Knigge 2005, 132 nr. 169, 147 nr. 276, 155 nr. 344, 159 nr. 378, 189 nr. 590; Villing and Pemberton 2010). The presence of these specialized commodities at sites far-away from their production centers is a good argument for the wide distribution of certain successful kitchen ware and probably for the adoption of some specific recipes. The gradual increase in the use of mortars, both locally produced and imported, implies that they became an integral part of the ancient Greek cooking methods.

An equivalent but heavier tool for grinding and pounding cereals was the wooden or more rarely stone mortar (*ὅλμος*) that had the form of a deep bowl on a high stand and was used with the help of a long wooden pestle (*ὕπερος*) (Sparkes 1962, 126; Villing 2009, 322-323). Such big mortars are common finds in Greek houses of the Late Classical and Hellenistic periods, as in Olynthus and Delos (Chatzidakis 2000, 124; Cahill 2002, 166-16); earlier vase and terracotta representations show generally two people, mostly women, tapping with large pestles into the vessel, in a scene of grain-processing either for everyday or ritual purposes (Pisani 2003, 13-14; Villing 2009, 323-328).

Along the known ancient Greek production places of cooking pots, the island of Aegina stands out during the Archaic and the Early Classical periods for the excellent quality, sophisticated technology, and the wide distribution of its clay products for cooking purposes (Haggis et al 2011, 442 note 26; Klebinder-Gauss 2012; Gauss et al 2015; Klebinder-Gauss and Strack 2015; Gauss and Klebinder-Gauss 2017). The production and the reputation of the Aeginetan household ware, especially water jars, remained alive in the traditional pottery workshops of Aegina that supplied the market of Athens and other areas until recently (see Kyriakopoulos 2015, 267 note 82). The round-bottomed *chytrai*, with or without lid, the shallow *lopades* and many other devices of the "batterie de cuisine" (braziers / *escharai*, ovens, grills / griddles, baking pans, sieves) display very good technical properties in terms of fabric, shaping, and surface treatment (polishing and burnishing outside, careful coating inside), underlining their effectiveness in cooking, baking and roasting (Klebinder-Gauss 2012, 175-176, 179-182; Gauss et al 2015, 69-71).

This cookware reached not only neighboring markets (as those of Corinth and Athens -the last despite the longstanding rivalry that existed between the two cities), but also much more remote areas on the coast of the Mediterranean and the Black Sea (for a distribution-map see Gauss and Klebinder-Gauss 2017, 31 fig. 13). At that time the Aeginetans played a leading role as ship owners and merchants in the overseas trade; one of them was Sostratos, son of Laodamas, famous for his commercial successes and his wealth (Herodotus 4.152). It is remarkable that such "unpretentious", locally produced items managed to wake the interest of buyers outside this small island and to find large-scale acceptance. The reputation of "pot selling" (*χυτρόπωλις*) Aegina lasted until its occupation from Athens in 456 BC and the expulsion of its population in 431 BC, although recent archaeological and archaeometrical research showed the probable continuation of the production of cooking ware from expelled Aeginetan potters that worked in Athens (Klebinder-Gauss and Strack 2015; Gauss and Klebinder-Gauss 2017, 29-30).

Cooking vessels manufactured in Corinth, fewer pots, and more mortars, had also a very good reputation from the Late Archaic era and during the Classical and Hellenistic periods. Made mainly from hard local coarse or tile ware they were highly durable and very sturdy, earning a great reputation and wide diffusion in other areas.

24.3 Conclusions

This overview of clay kitchenware and the related modes of cooking in ancient Greece has revealed an impressive level of sophistication in terms of transforming plants and other food ingredients into dishes for a large part of the 1st mill BC. The utensils and thermal installations we have examined demonstrate a great variability that supports the great variety of dishes that were prepared in the ancient Greek world as can be clearly seen in ancient Greek texts in the works of Athenian Comic poets, and other writers as Archestratus and Athenaeus for example. Portable cooking facilities show flexibility in marking the cooking area and constitute an interesting feature of the ancient Greek kitchen that differentiates it from many prehistoric contexts where hearths and ovens were fixed structures, marking specific cooking areas in the latter case. Specialisation in the manufacture of certain food preparation utensils used for grinding or cooking and the strong merchantile interest in trading culinary equipment demonstrates the importance of food preparation and the significance of specific tools with guaranteed properties, sometimes leading to the development of "brand" food preparation objects the production and trade of which lasted for decades or centuries. We can therefore trace in the ancient Greek world the development of renowned kitchenware, with which we are very familiar nowadays.

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Chapter 25

Preparing vegetables in ceramic pots over a hearth fire: using Minoan cookware to understand plant-based dishes in the ancient world

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Abstract

Seasonal greens and dried pulses are winter food sources for individuals living in the Aegean, both today and in the past. During the Aegean Bronze Age it was common for an individual to prepare food in a ceramic tripod cooking pot over fire, while today some form of metal pot is typically used on either a gas or electric stove. To demonstrate how these foods could be prepared using a ceramic cooking pot heated by a hearth fire, observational exercises were conducted and recorded in the winter of 2021 in a mountain village located in the southeastern region of Crete. Three plant-based dishes were prepared: golden thistle (Scolymus hispanicus, also called Spanish salsify and in the Cretan dialect ασκολύμπρους/askolibri), brown lentils (Lens culinaris or φακές/fakes), and mixed greens that include spiny chicory (Chicorium spinosum, also called σταμναγκαθι/stamnagathi) and dandelions (Taraxacum). Observational cooking exercises with Minoan-style ceramic pots and a hearth fire is essential to understanding the past, because it helps develop daily-life skills that merge practical and theoretical knowledge.

Keywords: *Minoan, cooking pots, ceramics, hearth fire, plants, legumes, pulses, leafy vegetables, experimental archaeology, Crete, Greece, Aegean*

25.1 Background

The legendary teacher Julia Child once proclaimed: "No one is born a great cook, one learns by doing!" This statement is particularly true when understanding the "how-to's" of age-old cooking technologies that our modern electric world has left behind. Since 2007 I have studied the ancient Cretan kitchen and have learned how to create and cook in ceramic cooking vessels and other utensils that resemble those made during the Neopalatial period (ca 1750 to 1450 BC) of the Cretan Aegean Bronze Age (Morrison 2017; Morrison et al 2015). Iconic Minoan ceramic cooking vessels used during this time period include the tripod cooking pot, the circular shallow tray (with lug or horizontal round handles; may have three legs), and the thin, shallow, oblong cooking dish whose one end is a broad shallow spout, and the other is a deep bowl (the cross section of the vessel resembles the shape of a scoop) (Betancourt 1980; Brogan and Hallager 2011 and the references therein). Accessory utensils are a rectangular shaped grill (Hemingway et al 2011, fig. 10a; for the Minoan Seminar hosted by the American School of Classical Studies in Athens and the INSTAP Study Center for East Crete in 2012, we prepared large pieces of meat and whole fish on an experimental ceramic grill) and "souvlaki stands" that were presumably used to grill smaller cuts of meat on the bone or sticks (for LM IB references in cooking spaces see Tsipopoulou and Alberti 2011; for experimental usage, see Hruby 2017).

While scholars understand much about Neopalatial ceramic and stone cooking tools and some of the food types prepared, comparatively less is known about the physical structure and location of the "Minoan kitchen" (or cooking spaces). A few explanations are that compared to other Minoan architectural features there appears to be a lack of standardization in the structure and location of the Minoan kitchen. Cooking spaces seem to be less plentiful when related to the vast quantity of ceramic materials and stone tools recovered during excavation that are attributed to food-related activities. Additionally, it can be challenging for excavators to initially identify a cooking space during excavation, because these are rarely permanent built stone or mud brick structures. Rather Neopalatial cooking spaces are commonly identified by broken cooking pots, a grey-to-white ashy soil often mixed with a darker colored soil that displays patches of a "greasy" texture and charcoal, macrobotanical remains (i.e. bone, shells, seeds), and accessory ceramic vases (i.e. bowls, basins, strainers, braziers), or stone tools.

Across the island it appears that people during the Neopalatial period cooked their food over an open fire in both indoor and outdoor semi-permanent spaces using ceramic vessels and often where other domestic-type activities took place. This leaves the impression that perhaps individuals prepared their food in places of convenience while simultaneously performing other seasonal or domestic tasks, or they prepared food in places to accommodate other needs (i.e. weather, quantity of food being prepared, number of individuals being served). In fact, the morphology of the tripod cooking pot lends itself to this type of mobile cooking use. This description of cooking in the Late Minoan I period come from site-specific accounts that have diligently and meticulously excavated, examined and published the artifacts and macrobotanical remains of administrative and town buildings (Shaw and Shaw 1995, 1996, 2006; Isaakidou 2007; Brogan and Barnard 2011; Shaw and Shaw 2012; Brogan et al 2013), ship sheds (Shaw and Shaw 2006), artisans' quarters (Soles 2003, 2004), and farmsteads or villas (Soles 2003, 2004)[1]. A few of these examples are outlined in the following sections.

1 These references list of sites that the author has researched extensively both by examining the ceramic material, interviewing the authors, and reviewing the publications. There are many more sites and important works understudy that will be included in a comprehensive review of cooking practices.

25.2 Principles of cooking methods and food sources in the Aegean Bronze Age

With the Minoan cooking kit one can simmer, boil, stew, sauté, roast, bake, and grill various types of food, yet one needs to understand the relationships among the food items, ceramic pot, and hearth fire, or the desired outcome will not be achieved. The food could be undercooked, or it could burn, and the pot could crack from mishandling. My proficiency acquired through experience demonstrates that one must be aware of four guiding principles of hearth cooking when using ceramic vessels and other utensils. These principles extend beyond the Minoan world to most cultural settings. First, one must know what type of ceramic vessel or utensil to use when preparing a particular dish to achieve a desired result. For example, to make a stew, one needs a closed, big-bellied pot. Second, cooking with fire requires knowledge of how to produce and maintain heat using wood and charcoal for the duration of a cooking session. Third, protecting the ceramic vessel ensures its longevity in use. It is very important to understand the relationship between the cooking fire and the thermal properties of the cooking ware in order to protect the ceramic vessel from cracking. This information can be gleaned through the use of the senses (i.e. touch or sight) or a thermocouple. Once this temperature range is understood, one needs to know where and when to place the hot coals in relation to the ceramic vessel to successfully cook the food. The fourth principle focuses on the final cooking phase when one must know when to stop placing hot coals around the pot in order to lower the external radiating heat and allow the internal radiating heat that is stored on the interior of the vessel (and within the matrix of the ceramic material) to finish cooking the food.

These principles manifest as specific actions that are often sequential in nature during the cooking process. Yet due to continuous problem solving throughout the process, the act of cooking remains nonlinear and multifaceted resulting in a slightly different outcome for each session. Often, the end cooking result can vary in taste and texture, and even the length of cooking time or the amount of fuel used can be variable. If the cooking principals are applied – and procedures and recipes are followed – and there is still variation in the final dish, one might ask: *How is this possible?*

Each time one cooks there are deliberate actions taken and omitted during the cooking process that are based on dependent and independent variables that influence the end result. Dependent variables are constant and often remain in the archaeological record as an object or a collection of objects. When discussing cooking practices in the Aegean these include cooking pots, hearth structures, food processing tools, as well as food and fuel debris (e.g. examples of cooking areas in Minoan towns of eastern Crete, for Mochlos see Soles 2003, 7-35, 36-38, 43-87, 107-112, 119; Brogan and Barnard 2011; at Papadiokambos, see Brogan et al 2013). Independent variables are less likely to manifest as a material object because these focus on the social aspects of cooking for a select group of individuals. Rather, these variables tend to be identified in the archaeological context indirectly and require interpretation beyond the basic identification of a material object. Independent variables, for my work, are organized in such a way that the physical spaces where people cook are created, which in turn influences how they prepare for the act of cooking. In the scenario presented in this paper, the variables that are of interest include the location and hearth arrangement in relationship to the house (i.e. indoors or outdoors), type(s) of food, and how the heat is produced for cooking (i.e. wood, charcoal), as well as the climate of the location (i.e. temperature, humidity, wind, sun exposure, and elevation).

Cooking is a multifaceted process that relies on nonlinear thinking and external factors. It is often idealized as a mystical talent that one is born with the ability to transform raw food into a delicious dish rather than a learned skill. Understanding the variability of the cooking process allows archaeologists to offer multiple interpretations of the ancient kitchen and to test their hypotheses through experimentation. As in a modern test kitchen, reliable cooking trials (experimental archaeology) are used to develop practical problem-solving skills that identify the components of ancient cooking and cultural markers. Researching the use of vegetables in the ancient world is challenging because only a fraction of the material culture is recovered during excavation. The recovery procedures of macrobotanical samples require organization (i.e. soil samples must be systematically collected during excavation and processed by water sieving in order to dry and store the botanical remains properly so they do not decay before sorting and identification), and chemical analysis has limitations when identifying specific plant materials, or it has unreliable sampling procedures (Payne 1972; Sarpaki 2012; Moody et al 2012, 251, 252). To complicate matters, ancient people most likely collected wild greens and herbs before the plants flowered and dropped seeds, and the processing methods they used also contributed to their invisibility in the archaeological record – i.e. seeds with high oil content explode when heated, disfiguring them beyond identification, and grinding foodstuffs also naturally impedes proper identification (Megaloudi 2005, 56; Moody et al 2012). In general, leafy greens have a fragile cellular structure that promotes quicker decay, which also contributes to the seemingly lack of representation in the archaeological record. For these reasons it is more common to identify fruits, nuts, and grains that have a more substantial seed coating and animal-based foods with bones or shells rather than leafy greens in the archaeological record (Moody et al 2012 and the references therein).

Due to differences in artifact preservation that lead to biases in data, archaeologists must exercise caution when drawing conclusions about the use of plant-based foods in the ancient world to include evidence that is both present and plausibly absent. On Crete, for example, after the eruption of Santorini in the Late Minoan period, there is direct evidence for the use of tripod cooking pots, most likely for simmering or stewing (Morrison et al 2015) brown lentils at Papadiokambos (pers. comm. C. Sofianou, 2010), a soup full of topshells, limpets, and crab also at Papadiokambos (Brogan et al 2013), and a wild hare stew at Mochlos (Soles 2003, 119). In these three scenarios only the pot with pulses provides insight into cooking plant-based ingredients in the past. No additional evidence was found from macroscopic or chemical residue analysis; the published discussion thus focuses on what has been identified.

25.3 Textual evidence for ancient cooking

From Minoan Crete, there is a dearth of textual evidence due to few surviving written accounts using Cretan hieroglyphs (ca 1625-1500 BC), Linear A (ca 1800-1450 BC), or Linear B (ca 1450-1200 BC) (Best 1972; Olivier 1986; Salgarella 2020) and the fact that only Linear B is deciphered (Chadwick 1958). Major cities and administrative centers on the Greek mainland and on Crete primarily used Linear B for economic administration by recording the disbursement of goods (i.e. wool, sheep, grain, olive oil, and wine) (Chadwick 1958). With the exception of listing types of skilled or unskilled personnel at Knossos, i.e. bread bakers, flour grinders, grain pourers, serving women, hunters (Isaakidou 2007, 10 citing Ventris and Chadwick 1973, 123), relatively little about food preparation and daily life has been found inscribed on the Cretan tablets. There is mention of spices, herbs, and condiments in the Linear B tablets; however, these flavor-enhancing items were often listed in the context of perfumed oil industry for the later Mycenaean palaces (Ventris and Chadwick 1973; Shelmerdine 1985; Isaakidou 2007). The oldest known cookery accounts are from Mesopotamia some 4,000 years ago (Bottéro 2002), and relationships between these two neighboring regions are well documented. Dishes are recorded on stone tablets from ancient Babylon and Assyria – what are today regions of southern Iraq and north of Baghdad, as well as parts of Syria and Turkey. Tablet A (catalogued as YOS II 25) has at least 25 lists of ingredients for broths and stews, in which 21 are animal based with vegetables and spices used as a seasoning (Bottéro 2002, 26-29). The clearest interpretations of plant-based dishes that appear to have been simmered or stewed are few, and they include:

- Gazelle broth (no. 6, lines 15, 16), "other meat is not used." Prepare water; add fat (possibly gazelle animal fat or another unknown animal product, most certainly *not* oil because in Tablet C oil *is* listed; Bottéro 2002, 34), salt to taste, onion, *samidu* (i.e. Assyrian samidus means "semolina," the finest flour, possibly used as a thickener, Kelly 2012), leek, and garlic (Bottéro 2002, 27).
- Bidsud(?) broth (no. 14, lines 37-39) that uses blood as a binder, with dill, crushed dodder (a group of ectoparasitic plant that have a thin, sting-like twining stem that appear to be leafless; it is known to have medicinal properties), onion, *samidu*, cumin, leek, garlic, and possibly a missing ingredient (Bottéro 2002, 27-28).
- Garden turnip broth (no. 25, lines 71-73), meat is not used. Prepare water; add fat (unknown animal, *not* oil because in Tablet C oil *is* listed; Bottéro 2002, 34); onion; arugula; coriander and cake crumbs (?) that are bound with blood; mashed leek and garlic (presumably mashed together because of Bottéro's punctuation in the translated text; Bottéro 2002, 29).

The broth, soup, and pie recipes recorded in the Babylonian tablets (Bottéro 2002, 25-35) appear to include various quantities of animal-based products – e.g. organ, fat, and blood. It could have been common for individuals in this region and at that time to rely on an unidentified proportion of animal-based products for their cooked dishes to provide taste and calories, as Tablet A (YOS II 25) demonstrates. Additionally, from a preservation viewpoint it would be unlikely that all of the ingredients listed would be recovered during an excavation as artifacts. Conversely, ingredients that are recovered may have been omitted from the ancient texts for reasons that are unclear. The insight provided by the Babylonian and Assyrian tablets is encouraging because they give Aegean scholars interested in the ancient kitchen a cultural statement of the types and combinations of foods that were prepared using techniques of simmering and stewing for specific tables in a neighboring civilization that was a critical component to the Minoan world.

Understanding that cooking is multifaceted and that only a small percentage of the past remains in the archaeological record, or recorded in some textual form, researchers can use experimental archaeology and experiential learning activities to reconstruct unpreserved foodstuffs and cooking practices that would have been essential to the ancient cuisine.

25.4 Observational exercises in hearth cooking with ceramic pots

The objective of this exercise is to explore and demonstrate how leafy greens and pulses can be prepared using a ceramic cooking pot and a hearth-fire to better understand how plant-based dishes could have been prepared in the past. In general, plant-based dishes are those whose primary ingredient are fruits, vegetables, pulses, or grains. While some ancient texts list mixing animal and plant products when cooking (Bottéro 2002, 25-35), a decision to omit animal-based products for this exercise was made to minimize variables. For this paper, the definition of the ancient kitchen includes both the material culture (i.e. dependent various – cooking pots, utensils, tools for managing the hearth-fire, food ingredients) and the social aspects of cooking (i.e. independent variables – observer's skill level, cooking techniques, climate, location of hearth), because the goal is to understand the act of cooking by deconstructing it to build explanatory models as to why we find what we find in the archaeological record.

For these cooking exercises modern and ancient Crete serves as the cultural contexts, because the bulk of my ceramic cooking knowledge is rooted in the Aegean. Modern Crete today uses techniques of simmering and stewing to prepare pulses and leafy greens – e.g. various warm χόρτα (*horta*) green salads and lentil, or chickpea soups. The plants chosen for this demonstration are native to the Mediterranean, and a variety of each type has most likely been available for individuals living on the island since the Neolithic period to either collect or farm as a food source for both humans and animals (Hansen 1991; Sarpaki 1992; Hadjichambis et al 2008; Moody et al 2012 and the references therein). Three plant-based dishes were prepared: golden thistle (*Scolymus hispanicus*, also called Spanish salsify and in the Cretan dialect ασκολύμπρους/*askolibri*), brown lentils (*Lens culinaris* or φακές/*fakes*), and mixed greens that include spiny chicory (*Chicorium spinosum*, also called σταμναγκαθι/stamnagathi) and dandelions (*Taraxacum*). Based on personal hearth cooking experience with local winter foods, I know that each plant-based dish will require a different cooking procedure using a tripod cooking pot and hearth-fire. This type of comparative demonstration of how different types of plant-based dishes react to time and temperature using ceramic cooking technology that is not well understood in our modern world is important, because often foods with a softer cellular structure do not remain in the archaeological record in large quantities. This invisibility makes it challenging for specialists to determine how these foods could have been prepared, if at all. Additionally, at least two of the plant-based dishes address seasonal cooking because the vegetables are available only during the rainy season when the weather is cooler.

25.4.1 Three plant-based dishes

While lentils have been farmed, or managed, in the Aegean for thousands of years (Hansen 1991; Sarpaki 1992), the golden thistle and mixed greens, until recently, would have been available only by foraging during the winter months.

Native plants like chicory, dandelion, and golden thistle are now commercially available due to the recent demand created by the revival of traditional culinary practices and the expansion of farming Mediterranean products in southern Europe[2]. To support the farming industry that is directly, or indirectly, helping to curtail inappropriate foraging of these plants, spiny chicory, dandelions, and golden thistle were purchased for this exercise.

To create a palatable dish, each plant-based product requires different cooking techniques. Wild greens can be eaten raw, wilted using a dry heat cooking method, or lightly boiled. The greens can be dressed with a mixture of olive oil and lemon juice (or vinegar) and topped with sea salt. For this exercise the mixed greens were wilted to create a more complex taste and texture. Golden thistle is usually slowly simmered with lamb and flavored at the end of cooking with an egg and lemon sauce. Here, it was cooked using a combination of dry heat and a slow simmer, and then it was dressed with vinegar and topped with sea salt. In Greece today, brown lentils are typically prepared as a soup with crushed tomato, carrots, onion, garlic, and herbs. For this exercise, the lentils are simmered with a minimal amount of liquid and crushed coriander, chopped onion, and a bay leaf. Once cooked, it is flavored with honey and topped with olive oil and sea salt.

25.4.2 Hearth location and cooking plan

The cooking was performed in Hagios Ioannis, Koutsounari, a mountain village located east of Ierapetra on the southeastern coast of Crete. This is where I spent the fall and winter months in 2020-2021. In general, Crete has a temperate Mediterranean climate with relatively mild, rainy winters and hot, dry summers. There are significant differences between coastal zones and mountainous areas, as well as between the western and eastern parts of the island. The southeastern region of Crete is the most arid and tropical on the island, yet in the winter there is high humidity in all elevation zones created by the mountain springs, saturated ground from snow and rain, strong southern winds off the Libyan Sea, and indoor condensation caused by the stark difference of temperature between the warmer, sunny days and chilly nights. This damp and cool environment slowly sets in after the autumn rains begin (October or November) and lingers until the end of May. The cold, humid indoor environment, which can be like a meat larder if unattended, affects the cooking process, and it is a critical component to understanding how to manage domestic life during the winter months on Crete. A priority for this period is to keep the house and the cooking hearth as dry as possible. This can be accomplished by opening the house to let the wind dry the air inside and then close the structure to warm it by any means of heat – i.e. oil, electric, and or a wood burning stove. Otherwise, it takes a considerable amount of time and energy to warm and dry out the hearth for cooking. This is an important distinction between "modern living" when people rely on electric or gas-powered stoves, or microwaves, to cook or warm our food, verses stoking the hearth through out the day. In short, if one is not utilizing the hearth (or fireplace) for warmth or cooking daily during the winter months, than like the rest of the house it becomes damp and cold. In this scenario, one must consider the amount of time and effort needed to warm the cooled hearth for cooking, as well as the house, to create a more efficient indoor cooking area. And while hearth-fire cooking in ceramic pots can be accomplished outdoors in both coastal and higher mountainous elevation zones across the island during the wetter months, one needs a relatively windless day and direct sun. For these reasons, the cooking experiments were held indoors within a fireplace constructed with firebrick. The golden thistle and lentils were prepared on the same evening, while the mixed greens were prepared a few days later.

25.5 Observations and results

A Minoan-style ceramic tripod cooking pot (ca 6 to 7 l) with a lid was used to prepare the golden thistle, mixed greens, and brown lentils. The shape and size of this cooking pot is similar to those found on Crete in Protopalatial and Neopalatial cooking areas (Betancourt 1980; Brogan and Hallager 2011, and the references therein; Morrison 2017). Previous cooking experiments with this shape and size demonstrate that it can be used to make broths, soups or stew with pulses, seafood dishes, and various cuts of meat both on and off the bone (Morrison et al 2015). Here techniques of simmering and dry cooking were used. The lentils were previously harvested and dried, thus requiring complete immersion in hot water to cook. The golden thistle and mixed greens were fresh, and they could be prepared using various methods. To retain the delicate texture of the mixed greens, a dry cooking method was used. A hybrid method of dry cooking to simmering was applied to the pot with the golden thistle because the ribbon root has a thick textural quality. The preparation and cooking details for each dish are organized by a sequential cooking time (Tables 25.1-25.3; Figs 25.1-25.3). To demonstrate how the *chaîne opératoire* of experimental cooking for each dish can be compared, they were mapped (Fig. 25.4).

The three plant-based dishes were prepared within 2 hours and 30 minutes, and as one might expect,

2 This is my personal observation while working in the food and tourist industries the last 10 years. I am aware that golden thistle and other foraged greens have been farmed in Spain, and perhaps Italy, for many years and perhaps this farming technology is being adopted in Greece. More research and interviews of green grocers and farmers are needed for the future.

Minoan-style Cooking of Golden Thistle (*Scolymus hispanicus* or Ασκολύμπρους/*Askolibri*)			
Cleaning time 1 hour and 47 minutes for 1 kg			
Cooking time including lighting the fire is ca 2 hours and 15 minutes (17:46 to 20:00).			
Cooking time for the food is ca 1 hour and 46 minutes (18:14 to 20:00).			
Time	**Action**	**Temp °C**	**Sequential Cooking Duration**
15:50-17:37	Cleaned 1 kg by removing the thorns from the edges of the stem and cut the ribbon roots from the stem; fingers were discolored (Fig. 1:A).	Not recorded	1 hr., 47 mins.
17:46	Started fire with three pieces of wood in the back right corner of fireplace with a strong updraft (Fig. 25.1b). Poured 1/2 cup of olive oil into pot, added sliced ribbon roots, and closed pot with a lid (Fig. 25.1c).	Not recorded	Start
18:23	Soft steam. Temperature recorded on interior and exterior of pot (Fig. 25.1d). Color of the root changed from a light cream to green to a slightly transparent cream to pink to green.	53 °C (pot int.); 94 to 108 °C (pot ext. toward fire); 45 °C (pot away from fire)	37 mins.
ca 18:30	Added hot coals around the base of the pot (Fig. 25.1e).	Not recorded	13 mins.
18:46-18:53	Soft steam when lid removed. Hard sizzle when stirring contents of pot, especially when food touched hot dry sides of pot. Changed color and more translucent (Fig. 25.1f).	61 °C (pot int.)	46-53 mins.
19:00	Broke the burned wood into coals to warm the pot, air around it, and the fireplace. The sides of the fireplace were warm, and the exterior of the pot was very hot to the touch. Sizzled as the steam condensed on the interior surface of the lid, and the water droplets fell into the hot oil. To retain heat, kept the lid on the pot.	Not recorded	7-14 mins.
19:06	Heard slight sizzle inside the pot. Placed thin stem parts on top of roots in pot; did not stir. These pieces had been soaking in water (Fig. 25.1g).	49 °C (pot int.); 92-93 °C (pot ext. toward fire; 47-82 °C (pot ext. away fire)	6 mins.
19:35	Stirred the stem and root pieces together inside the pot.	61 °C (pot int.)	29 mins.
19:45	Added 350 ml of room temp water mixed with sea salt.	85 °C (pot int.)	10 mins.
20:00	Stems and roots were "steamed" like a warm salad. (Liquid did not boil.) Stem pieces were nice to eat, but the thicker root pieces were tough. They needed to be cut smaller and cooked longer (Fig. 25.1h) or blanched in advance. Color was green to tan and cream to translucent.	66 °C (pot int.)	15 mins., finished

Table 25.1 Procedure for cooking golden thistle in a Minoan-style tripod cooking pot on a hearth at Hagios Ioannis, Ierapetra, December 27, 2020.

preparing the mixed greens using a dry cooking method took less time (1 hour and 30 minutes; Table 25.3; Fig. 25.3), while simmering the brown lentils took the longest time (2 hours and 25 minutes and then resting in the hot pot over night; as it rests in the pot the food continues to slowly cook until the pot has cooled, this can take 30 minutes to 2 hours depending on temperature of the cooking pot, how much food is inside and it's density, as well as the exterior temperature and time of day – this all comes with experience; Table 25.2; Fig. 25.2). Although the mixed greens took the least amount of time, it was considerably longer when using a ceramic pot and hearth fire to dry cook a batch compared to using a metal pan with gas or electric heat. The most laborious task was cleaning the golden thistle by removing the thorns from the edges of the stems and patches of discolored and hard exterior coating on the ribbon root (Fig. 25.1a, c). The discolored and harder patches of the ribbon root indicate that it was not freshly harvested. The brown lentils retain their shape, color, and flavor when simmered with a minimal amount of water needed to rehydrate and cook them. This approach minimizes enzyme damage to vitamins and pigments and allows the seed coating to stay intact so that each lentil retains its shape and does not disintegrate (McGee 2004, 487, 492). While the lentils took the longest to prepare, it takes less time than other pulses common in the Mediterranean, i.e. broad beans (*Vicia faba*), chickpeas (*Cicer arietinum*), black-eyed peas (known today as *Vigna unguiculata*), and navy beans (*Phaseolus vulgaris*) (McGee 2004, 490-492). Additionally, allowing the lentils to rest overnight in the pot allowed them to continue to cook and absorb the cooking liquid so that the final texture was creamy and the taste was sweet (Table 25.2; Fig. 25.2d).

25.6 Discussion and conclusions

This study explores how hearth cooking with a lidded ceramic pot was used to prepare three native Mediterranean plant-based dishes. Cooking in ceramic pots has a longstanding tradition in the Aegean believed to have begun during the Neolithic period and lasted until the middle of the 20th c (Betancourt 1980). To explore how plant-based dishes responded to this type of ancient cooking technology, three exercises were conducted and recorded to demonstrate how "invisible foods"–those that

Minoan-style Cooking of Brown Lentils (*Lens culinaris* or Φακές/*Fakes*)			
Cooking time for the food ca 2 hours and 25 minutes (20:20 to 22:45; rested overnight).			
Continued to use the same fire from previous dish (see Table 1).			
Time	**Action**	**Temp °C**	**Sequential Cooking Duration**
20:20	Removed the golden thistle and added 1 kg dry brown lentils, crushed coriander, and boiled water (Fig. 25.2a); note dry lid.	63 °C (pot int.); 60-82 °C (pot ext. near fire); 38 °C (pot ext. away fire)	Start
20:33	Lentils soaked up water; added cool water to cover the lentils.	Not recorded	13 mins.
20:45	Steam rose slowly from pot.	66 °C (pot int.)	12 mins.
21:25	Steam with a small boil at perimeter closest to fire. Faint sweet legume aroma. Water level looked equal to the lentils until stirred; then they fell to the bottom of the pot (Fig. 25.2b).	82 °C (pot int.)	40 mins.
21:35	Added wood to the fire. Needed more water, so added 300 ml room temp water. Lentils had a medium to hard texture.	Not recorded	10 mins.
21:45	Liquid is brown. Steaming, not boiling. Sweet aroma of lentils.	Not recorded	10 mins.
22:15	Slow boil. Lentils have medium to soft texture.	75 °C (pot int.)	30 mins.
22:18	Condensation under lid is visible on the exterior; harder color (Fig. 25.2c). Moved the pot closer to the fire.	Not recorded	3 mins.
22:45	Slow boil. Skin of lentils peeled off, soft, but not fully cooked. Starchy taste. Water from lid remained on surface of hearth floor when it was removed from pot and placed there to rest.	66 °C (pot int.)	27 mins.
22:57	Lentils unevenly cooked; some had a softer texture.	72 °C (pot int.)	12 mins.
23:15	Final cooking stage; moved coals around the base of the pot. Heard boil and sizzle of lentils. Liquid with bubbles noted between the lid and rim of the pot.	67 °C (pot int.)	18 mins.
23:28	Strong boil within the pot. Still watery, but could be served. Broke down coals and moved them around the pot.	67 °C (pot int.)	13 mins.
22:45	Strong boil still. Remove pot from hearth; let lentils rest overnight covered with cloth.	77 °C (pot int.)	17 mins., finished
Dec. 28, 9:00	All of the water has been absorbed. Top surface is a darker brown with a velvety texture (Fig. 25.2d).	23 °C (pot int.)	Rest overnight

Table 25.2 Procedure for stewing brown lentils in a Minoan-style tripod cooking pot on a hearth at Hagios Ioannis, Ierapetra, December 27-28, 2020.

have not survived in the archaeological record – could be prepared. Compared to food products and diets based on animal protein, grains, and pulses, there is a striking absence of discussion in the Aegean prehistoric literature about foraging, farming, and the preparation of plant-based foods for consumption. This gap in the discussion of food sources is most likely caused by the poor preservation of plant-based foods in the archaeological record and excavating methods to recover them. As more excavations utilize methods to recover plant-based materials and experts are able to study and publish, our understanding of this seemingly invisible world will most certainly continue to grow. Additionally, experimental archaeology broadens the researcher's knowledge of food resources in the past to include those that might have been available and consumed but invisible on a large scale to researchers today.

While I have experience preparing different types of dishes in ceramic cooking pots using a hearth-fire, this is the first time a systematic preparation of leafy greens and lentils was made indoors during winter in a non-coastal zone on Crete. Each plant-based dish could be prepared using a Minoan tripod cooking pot, but they required a slightly different cooking technique or variation of the technique. The success rate of developing domestic cooking analogies by utilizing these sorts of exercises is higher if the dependent and independent variables can be clearly defined and if the knowledge of hearth cooking with ceramic pots is sufficient enough to prepare food (see Methodology section). Below is a summary of each dish prepared (Fig. 25.4).

- A dry heat cooking technique was used for the mixed greens to retain a crisp texture and create a flavorful liquid that was highlighted with lemon, or vinegar, and sea

Minoan-style Cooking of Mixed Greens: Chicory (*Cichorium spinosum* or Σταμναγάθι/*Stamangathi*) and Dandelions (*Taraxacum*)			
Cleaning time 45 minutes for 1.5 kg			
Cooking time including lighting the fire is ca 1 hour and 36 minutes (20:54 to 22:30).			
Cooking time for the food is ca 1 hour and 30 minutes (21:00 to 22:30).			
Time	**Action**	**Temp °C**	**Sequential Cooking Duration**
19:50	Night before, cleaned 1.5 kg greens (45 mins). Removed decaying leaves, but did not cut the "bouquet" ends. The harvest cutting technique intertwined the "bouquets" (Fig. 25.3a). Greens soaked in water (4 to 5 hrs), rinsed, and left in cool spot covered with a cotton cloth.	Not recorded	45 mins.
20:54	Lit fire with three medium logs. Slow to start because wet wood and cold fireplace (Fig. 25.3b). Placed all greens in pot; no water (Fig. 25.3c). Full.	16 °C (pot int. no fire); 28 °C (pot int. fire)	Start fire (6 mins.)
21:00	Slight steam. Greens started to wilt and darken. Good fire; moved pot closer to fire farther inside fireplace.	95 °C (pot ext. towards fire; 27 °C (pot ext. away fire)	start
21:10	Rotated the pot 180° to evenly distribute heat around the food.	Not recorded	10 mins.
21:21	No steam. Greens on top were bright green; those on the bottom were darker green and wilting. Moved coals to warm both sides of pot.	54 °C (pot int.)	11 mins.
21:27	Slight bitter green aroma; lid remained closed. Greens were "sweating," wilting, turning dark green. No steam.	Not recorded	6 mins.
21:30	Greens wilted; easily pushed to bottom of pot (Fig. 25.3d).	45 °C (pot int.)	3 mins.
21:36	Steam rose when lid was removed from pot. Stirred; top layer was darker green and bottom was brown (Fig. 25.3e). Rotated the pot 180° to evenly distribute the heat around the pot. Condensation that collected on underside of lid left spot on hearth when lid was placed there.	37 °C (pot int.)	6 mins.
21:51	Stronger bitter green smell. No condensation was collected underneath lid. Added 500 ml water, pushed greens into the pot so water covered them. Wanted them to "steam."	Not recorded	15 mins.
22:00	Fire was going, but added small log. Moved pot to the back of fireplace; placed coals around it. Stirred the greens and flipped them so top greens went to bottom.	Not recorded	9 mins.
22:19	Steaming and sizzling. Greens were cooked unevenly; mixed green to brown colors (Fig. 25.3f). Condensation that collected on underside of lid left spot on hearth when lid was placed there.	65 °C (pot int.)	19 mins.
22:30	Finished. There was liquid in the pot, and the greens had a medium to soft texture (Fig. 25.3g).	58 °C (pot int.)	11 mins., finished

Table 25.3 Procedure for cooking mixed greens in a Minoan-style tripod cooking pot on a hearth at Hagios Ioannis, Ierapetra, December 30, 2020.

salt. Using modern technology, mixed greens can be eaten raw, steamed, boil, or fried. This offers flexibility when considering how it was used in the past, because more types of cooking techniques can be applied to cooking process for vegetable-based foods. Based on the literature and experience, it would be unusual to find this food preserved in a cooking pot on Crete at a Bronze Age site.

- The golden thistle was cooked with a combination of dry heat and a slow simmer with minimal amounts of liquid can. Most likely the cooking time could have been shortened, and all of the pieces would have still been soft, if a simmering technique was used alone. Using less water did not allow for the larger, harder, and thicker ribbon root pieces to soften enough for a pleasant bite, while the stem pieces and thinner ribbon pieces were well cooked. The ribbon root needs more systematic preparation (i.e. same sized pieces). Perhaps parblanching[3] would help to soften the root before final cooking (Rombauer and Becker 1975, 305). When cooked with lamb or rabbit in an egg-lemon sauce, it was much more delicious than the preparation described here. Presumably, it might be unique to find this plant-based food preserved in a cooking pot on Crete at a Bronze Age site. Perhaps only the bones of a lamb or rabbit would remain.

- A slow simmer that uses minimal amount of water is an excellent approach to preparing the lentils, especially

3 "Parblanch: place food into a large quantity of cold water, bring slowly to a boil, uncovered, and continue to simmer it for the length of time specified for partial cooking. Following this hot bath, the food is drained, plunged quickly into cold water to firm it and to arrest any further cooking, and then finished as directed by the recipe" (Rombauer and Becker 1975, 154). This technique is typically used to remove salt, strong flavors, and excess blood from cured and strong meats.

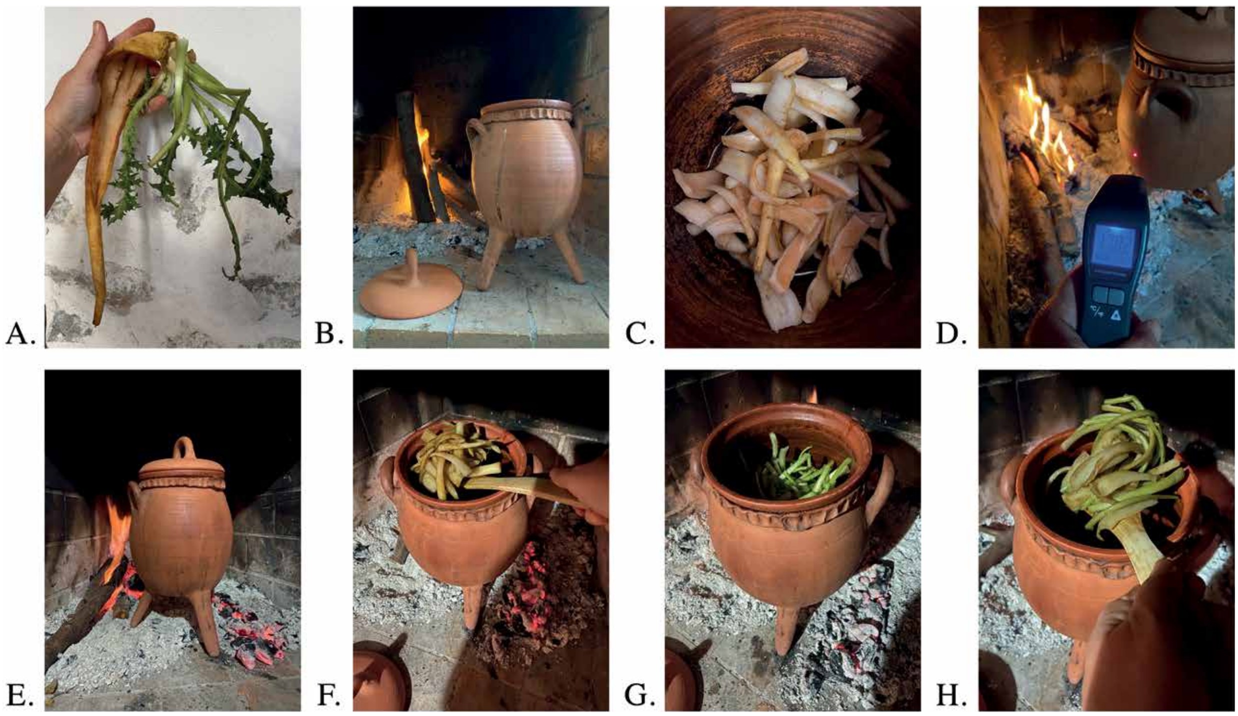

Fig. 25.1 The preparation of Golden Thistle in a Minoan-style tripod cooking pot on a hearth in Hagios Ioannis, Ierapetra, December 27, 2020. a plant with spiny stem and ribbon root before cleaning; b starting hearth-fire; c starting cooking by pouring olive into the pot with the golden thistle; d recording the temperature; e maintaining the hearth-fire; f golden thistle changes color as it cooks; g place stem parts on top of the root into the pot; h stems and roots pieces are "steamed."

Fig. 25.2 The preparation of Brown Lentils in a Minoan-style tripod cooking pot on a hearth in Hagios Ioannis, Ierapetra, December 27, 2020. a ingredients are in the pot, note dry lid is a bright orange color on the exterior; b water level and lentils are equal when stirred; c as steam rises from the interior of the pot it forms condensation on the underside of the lid that seeps through, note darker color sections that look like a stain; d lentils are finished, rested overnight, velvety texture with darker color on top.

Fig. 25.3 The preparation of Mixed Greens in a Minoan-style tripod cooking pot on a hearth in Hagios Ioannis, Ierapetra, December 30, 2020. a samples of chicory and dandelions; b starting hearth-fire; c greens into the pot that is placed on the hearth; d greens wilted and can be pushed to the bottom of the pot; e stirred greens, top layer is a lighter green than the darker bottom layer; f finished can see how much the greens wilted.

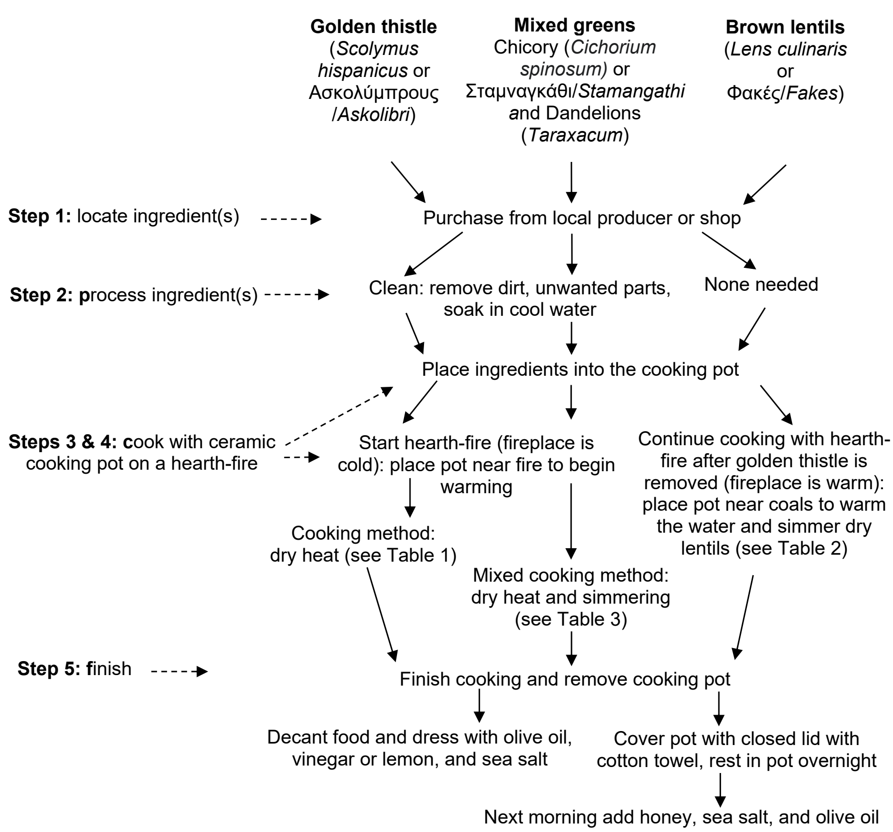

Fig. 25.4 *Chaîne opératoire* of Preparing Golden Thistle, Mixed Greens, and Brown Lentils in a Minoan-style Tripod Cooking Pot using a Hearth-fire.

when they are left to rest overnight in the pot away from the hearth-fire. This allows the lentils to retain their shape and a higher level of nutrition. The concern is that when using this technique it is easy to burn the lentils, so one must be careful. Experience helps with this. Burnt lentils often look very similar to those found in pots in the archaeological record.

Additional work in ceramic hearth cooking

The observational cooking exercises presented here is the start of a new exploratory series for Minoan-style cooking experiments that compares cooking techniques and spaces. This project has been ongoing since 2007, and revisions and updates must be made. An accompanied revised literature review for food remains and preparation deposits is needed, as well as an updated theoretical framework and incorporation of video.

Acknowledgements

This study is dedicated to individuals that find pleasure in playing with food and fire! My curiosity of how to present the practical knowledge of using pottery and fire while cooking to build bridges to the past and to each other would not be possible without the generous and continual support of my closest friends, family, and mentors. I owe a debt to each of you.

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Chapter 26

Glume wheats in modern Greece: lessons for antiquity

Paul Halstead

Abstract
Glume wheats were the dominant dietary staples of much of later prehistoric and early historic Europe, but had largely been abandoned by the 20th c AD. As a result, knowledge is rather sparse of their traditional methods of husbandry and consumption, despite its importance both as a component of European cultural heritage and as essential information for historians and archaeologists/archaeobotanists researching the history of farming and food ways. This chapter contributes to such knowledge on the basis of interviews primarily with elderly farmers who grew einkorn in northern Greece in the early to mid 20th c but also with younger informants in Greece who have recently taken up cultivation of emmer, spelt or einkorn. The observations of both groups of informants, with regard to the growing and consumption of these glume wheats, largely replicate previous reports from the west Mediterranean and Turkey, but also offer some newer insights. Also of interest are the rationales offered for the recent resurgence of glume wheats in Greece, which range from well-founded interest in their potential for organic cultivation to groundless appeals to a largely fictitious alimentary history. The chapter concludes with brief consideration of possible implications of the experiences of recent glume-wheat growers for late prehistoric and early historic farming in Greece and beyond. One important issue addressed is the potential suitability of the glume wheats for intensive, high-yielding husbandry, despite their frequent relegation in the recent past (especially in the case of einkorn) to cultivation on land too poor to support more demanding crops of free-threshing wheat. Finally, the possibility is noted that crop choices in antiquity may have been shaped not only by practical considerations, for example of growth requirements and suitability for particular forms of consumption, but also by the kind of culinary "invented tradition" that has underpinned recent demand in Greece for emmer and spelt wheat.

Keywords: *einkorn, emmer, spelt, glume wheats, kaploutzas, Greece*

26.1 Introduction

In common with most of the rest of Europe and adjacent western Asia, glume wheats played a central role in early farming economies of Greece, with emmer (*Triticum dicoccum*), einkorn (*T. monococcum*) and so-called "new" type glume wheat (*T. timopheevii*) cultivated from the 7th mill BC and spelt (*T. spelta*) from the 2nd mill BC (Halstead et al this volume). Glume wheats were still grown and consumed in early historical Greece, but – as elsewhere – were losing ground to free-threshing wheat and there is heated debate as to the extent to which glume wheats were still cultivated in early 20th c Greece. Cultivation of emmer, einkorn and spelt, however, has resumed widely in the last few years.

This chapter presents the results of research into the cultivation and consumption in Greece of einkorn in the early to mid-20th c and of emmer and spelt in the early 21st c, drawing primarily (for obvious practical reasons) on oral-historical interviews in the former case and on a combination of interview- and internet-based research in the latter. In both cases, the practices of modern farmers and their rationales for growing glume wheats during the last century were explored for the light they might shed on ancient cultivation and consumption of these crops.

26.2 "What (on earth) are you doing?" Einkorn growing in the early-mid 20th c

During the 1990s, I learned that staff at the Cereal Institute (*Institouto Sitiron)* in Thessaloniki were growing einkorn from seed corn originally collected among "Thracians" living in villages near Katerini in the northern Greek region of Pieria. I presumed that these Thracians were refugees (and their descendants) who had arrived from Eastern Thrace (now European Turkey) in the 1920s. From 2000 onwards, spending several summers in the predominantly East Thracian community of Paliambela-Kolindrou, promisingly located between Thessaloniki and Katerini, I fruitlessly questioned numerous elderly residents about "old cereals that were difficult to thresh". My luck changed quite unexpectedly in 2008, when an East Thracian from Paliambela-Kolindrou invited me to meet a friend of his at a taverna in nearby Aiginio. The friend was descended from refugees from *Northern* Thrace or Eastern Rumelia (*Anatoliki Romulia*), in southern Bulgaria, and it soon became clear that this was the sort of Thracian I should have been looking for. At some point during consumption of excellent *patsás* (tripe), our new acquaintance commented on an exchange between two neighbouring tables: one elderly North Thracian had asked another "Ti káneis?" ("What/how are you doing?") and received the reply "Kaploutzá spérno" ("I'm sowing einkorn"). The reply was a catch phrase among older North Thracians and implied that the speaker was doing nothing significant – because einkorn was considered hopelessly unproductive.

Over the following two years, together with a North Thracian archaeology graduate from Aiginio, I questioned many of her elderly compatriots who identified Kavakli (now Topolovgrad), Akbunar and Megalo Monastiri in Eastern Rumelia as their (or their parents') place of origin. I subsequently spoke to further elderly North Thracians, who hailed from Kavakli, Megalo Monastirio and also Bana (now Bania) and had settled at Kitros in Pieria, Mega Monastiri in eastern Thessaly and Neo Monastirio in southwest Thessaly. Among interlocutors born in southern Bulgaria between 1906 and 1925 or in northern Greece in the late 1920s and early 1930s, the dialect term for einkorn, *kaploutzás* (often pronounced *kapourtzás*; of Turkish origin – Ertuğ 2004), commonly elicited a positive response. At the time of interview, these informants ranged between their early 70s and 105 years of age.

Informants' knowledge of einkorn was very variable. Many were familiar with the refrain overheard in the Aiginio taverna ("I'm sowing einkorn" ["I'm doing nothing"]), but for some this was the limit of their knowledge. Thus one informant was aware that *kaploutzás/kapourtzás* used to be grown among the Kavakli community in Aiginio, but proceeded to describe a summer crop that sounded like common millet (*kekhrí, Panicum miliaceum*), while a second had concluded from descriptions by the first generation of refugees that einkorn resembled the common weed, darnel (*Lolium* sp.). To a third Aiginio informant, the catch-phrase "I'm sowing einkorn" meant "I'm doing nothing, I'm lazy", while a fourth in Neo Monastirio (born in the early 1940s) recalled the word as a synonym for "idler". A few could describe the einkorn plant (e.g. "a narrow ear, narrower than rye, with two rows of seeds"), having asked their parents about an unfamiliar cereal seen growing in a neighbour's field or as a weed among their own free-threshing wheat (*Triticum aestivum* or *T. durum*), while others remembered the growing, processing and consumption of einkorn in some detail.

Thodoros, born in 1906 at Megalo Monastirio in Northern Thrace, started working in the fields at ten or twelve years of age and left southern Bulgaria at 19. His family did not grow einkorn back home because they had a lot of fields with rich soil, while others sowed it on poor land at higher altitude that was "all stones", but it could be grown anywhere and yielded more on good fields or (from hearsay) after manuring. Similarly, after their removal to northern Greece, North Thracians in Aiginio, Kitros and Mega Monastiri recall the sowing of einkorn ("like barley") mainly on poor hill-slopes, but not exclusively so. Dimos' father sowed einkorn (and other undemanding cereals and pulses) on the slopes above Aiginio, where it grew shorter than free-threshing wheat ("to waist-high"). Even on the plain below Aiginio, some fields were poor and Dokas remembered his father once sowing einkorn sparsely (due to shortage of seedcorn) in the late 1920s on a sandy plot, prone to flooding, near the Akbunar suburb of Aiginio; he had harrowed in the seed and they harvested a sparse crop the following summer. Khristos in Kitros also praised the ability of einkorn to flourish on poor fields, whereas on rich land, or land recently manured, it was liable to grow too tall and so to lodge. His awareness of this risk of course implies that einkorn was also sown on fertile soil and manured land and, as Khristos also remarked, it was somewhat protected from the risk of lodging by its strong straw.

Einkorn was sown broadcast, as spikelets rather than free grain, in early autumn (October-November or even September-October) at the same time as, or following, free-threshing wheat. It tillered strongly ("10" or "12-14" tillers from one seed) and so, like barley and oat, could be sown on very weedy fields because it smothered competitors; for the same reason, Khristos in Kitros recalled that he weeded free-threshing wheat but not einkorn. According to the same source, the sowing rate was "1.5 or 2 tins of 7-8 *okádes* [9-10 kg] each per *strémma* (0.1 ha)", meaning something like 150-200 kg of *spikelets* per hectare and thus much lighter than the usual range for free-threshing wheat in mid-20th c lowland northern Greece of 150-200(/250) kg *grain* per hectare (Skorda 1979, 30; Halstead 2014, 31).

Ripe einkorn (with ears that turned downwards, rather like those of barley, according to Dimos in Aiginio) was harvested with sickles (its abandonment as a crop predated the arrival of mechanical reapers) in June, after barley and more or less at the same time as free-threshing wheat. Like the latter, it was reaped dead-ripe or slightly "green", depending on availability of labour, but the wind did not scatter the grain from the ripe crop, unlike that of barley, nor did the ears fall, as was the case with free-threshing wheat, while the glumes also provided protection from sparrows. Dimos and others found the tough and slender but pliable stems of einkorn more difficult to harvest, however, than those of free-threshing wheat, since they were liable to slip out of the hand or wooden reaping "glove" (*palamariá*) and were harder to cut. On the other hand, Anastasia in Kitros found that the shiny stems of einkorn, although hard to grasp firmly, "did not dirty us like the other wheats". Moreover, the qualities that made reaping difficult also reduced the risk of lodging ("it did not fall in rain") and, if this did occur, Thodoros described how lodged einkorn could be harvested with rakes, whereas lodged free-threshing wheat may not be salvageable (Halstead 2014, 197-198). Returning to harvest of standing einkorn, it was cut at mid-height if the straw was not needed for fodder. Because it was difficult to hold firmly and to cut, it was gathered in smaller handfuls than free-threshing wheat, but then, like the latter, was tied (with einkorn stems) into larger sheaves that were placed on the same day into stooks (or, if too few, were set upright leaning against each other). These stooks (*doukourtzínia*) remained in the field until the time came to transport the crop to the threshing floor.

Once the crop was thoroughly dry, it was threshed. According to Khristos in Kitros, it was flailed by hand if the quantity was small or the straw was to be used for roofing sheep pens, but by common consent it was usually trampled by the hooves of cattle aided by a sledge fitted with stone inserts (threshing floors in lowland northern Greece were unpaved). The difficulty of chopping the tough but flexible straw made threshing particularly slow and indeed some informants attributed the final abandonment of einkorn growing to the post-WWII arrival of threshing machines, which could not chop its straw as finely as needed for use as fodder. The end product of threshing was spikelets (i.e. grains still tightly enclosed in their protective glumes), "like [hulled] barley", and this gave rise to another popular expression among North Thracians, at least in Aiginio: someone heavily dressed for cold weather would be told "*ntúthikes kaploutzá*" ("You're dressed like einkorn"). A practical consequence, according to Dokas, was that winnowing was slow because the breeze tended to carry the spikelets off with the straw (as also with hulled barley mixed with free-threshing wheat – Halstead 2014, 134-135). For the same reason, if the spikelets were then sieved on the threshing floor (e.g. if the winnowing breeze was weak), a coarse sieve (*dermóni/dromóni*) for barley or maize (with larger apertures than that for free-threshing wheat) was used. These drawbacks were offset, according to Khristos in Kitros, by the immunity to weevils, 'unlike [hulled] barley', of stored einkorn spikelets.

Whether from personal experience or hearsay, most informants regarded einkorn as having been used overwhelmingly or exclusively as fodder for sheep, pigs (e.g. Dimos: "if we did not have maize" for the household pig), hens and especially cattle and buffaloes, but Thanasaina in Aiginio insists that it was not fed to horses. Khristos in Kitros further suggested that the scale on which a household grew einkorn depended on their number of livestock, for example 0.7-1.0 ha for five cows. He reckons that einkorn did not need to be winnowed thoroughly because the spikelets (but not the straw) were used as fodder – without further processing (the sharp awns having been removed by the sledge during threshing). Most informants, however, including Anastasia and Khrysoulla in Aiginio, described spikelets as being coarsely ground and/or soaked (even in hot water) before feeding to livestock, in the case of cattle mixed with (or on a bed of) chopped straw. Thus the chopped straw normally *was* used as fodder.

Thodoros recalls that, at Megalo Monastirio in southern Bulgaria, "those who sowed einkorn ate it, whereas they fed barley to livestock", and that the former was ground to flour in a water mill or a "hand-mill" [sic] turned by 2-3 people. The spikelets were evidently de-husked beforehand (he did not mention how), because the resulting chaff was fed to sheep mixed with the "resin" of manna ash (*Fraxinus ornus*). In Mega Monastiri, Dimitris's father had grown einkorn for bread and, before 1940, there was a dehusking machine in the village although Dimitris had not seen it in operation. In Aiginio, both Dokas and Dimos had heard of, but not witnessed in person, neighbours dehusking einkorn "like rice" at the mill or by pounding manually, respectively, while Nikolaos had heard from his father that it was de-husked with a wooden tool before grinding to flour to make bread. Eusebia had heard that people in Aiginio avoided eating einkorn because on one occasion they had done so and become dizzy, "as if they were drunk". In a similar vein, Dokas thinks that only the poor ate einkorn when very short of food and, as is well documented elsewhere in such circumstances (Camporesi 1980), they may not have cleaned the crop of weed seeds and chaff to avoid reducing its volume. Einkorn infested, for example, with fungus-infected darnel (*Lolium* sp.), similar to the crop in appearance and growth habit (and apparently confused with it by one informant – above), could have had the reported effect.

No other informant remembered this problem, however, and several conversely insisted that einkorn flour made good bread. In Thodoros' memories of his early life in southern Bulgaria, einkorn flour (sometimes, at least, mixed with that of other wheats) made "the best bread". In Aiginio, Petros maintained that, again mixed with flour from free-threshing wheat, it made good risen bread with a yellowish colour.

Despite its reputation for low productivity, encapsulated in the expression "I'm sowing einkorn" (= "I'm doing nothing"), Khristos in Kitros reckons that it yielded up to 200-300 kg/*strémma* (2-3 tons/ha) in the 1930s, albeit on land that perhaps still benefited from fairly recent clearance of light woodland in the years following their arrival in 1925, but its main attraction to North Thracians was its ability to thrive (and out-compete weeds) on poor soils and, in common with other undemanding cereals (particularly barley and oats), it was increasingly grown for fodder rather than food during the 20th c. Some North Thracians had abandoned it altogether before they moved to Greece and most did so before World War II. The difficulty of de-husking presumably contributed to its demise as a food crop, while its post-war disappearance as a fodder crop in Pieria was variously attributed to the adoption of labour-intensive tobacco as a cash crop and the associated abandonment of cattle rearing (with its attendant need for fodder) or to the introduction of threshing machines that could not chop einkorn straw finely enough for consumption by livestock.

Finally, despite the North Thracian focus of the previous paragraphs, einkorn was also grown in northern Greece within living memory by other communities. For example, as a teenager in the 1950s, the now-retired agronomist, Thanasis Zamanis, reaped einkorn (with a sickle) at Kipourio in the foothills (ca 800 m above sea-level) of the Pindos Mountains to the west of Pieria. The crop grew quite tall and sometimes lodged, but, as in Pieria, could be salvaged because the stems did not break. He reckons that it yielded well over one ton/ha (>100 okádes/strémma) without fertiliser on very poor soils and was abandoned when post-war availability of chemical fertilisers enabled higher-yielding and more easily processed free-threshing wheats to be grown on infertile hilly soils. The flour, which some mixed with that of (free-threshing) bread wheat, was used especially for pies, but also for bread, including loaves offered (*prósfora*) in church in liturgical contexts (Zamanis pers. comm.).

26.3 Economic crisis and past glories: glume wheats re-discovered in the 21st c

After more than half a century of almost universal abandonment in Greece, the cultivation of glume wheats has resumed recently, especially in the aftermath of the economic crisis that gripped the country from 2009 onwards, and is widely encountered from Macedonia and Thrace in the north to Crete in the south. Cultivation of emmer, spelt and einkorn, in apparently descending order of popularity, ranges in scale from successful commercial undertakings to small-scale "hobby" farming and uses seed-corn often imported from Italy or Germany (and even Afghanistan) in the case of emmer and spelt. Most of the einkorn now grown derives from north Greek *kaploutzás*, but local origins are also quite widely claimed, with varying degrees of implausibility, for current emmer crops (e.g. https://www.eleftheria.gr/αγροτικά/item/104429-η-«κιβωτός-του-νώε»-για-τους-σπόρους-στο-δίλοφο-φαρσάλων.html). In the following paragraphs, I first present some comments on the growth cycle and performance of these cereals, based occasionally on participant observation and mainly on interviews with cultivators in the Pieria region of Macedonia, in western Thessaly and in central and eastern Crete. I then discuss the rationales for growing these glume wheats as expressed both in interviews and in online blogs.

Unsurprisingly, some farmers cultivating these glume wheats for the first time have had to establish appropriate sowing and husbandry regimes by trial and error. Thus Damianos at Koukkos in Pieria tried sowing emmer as both free grain and spikelets, finding the latter much more effective because de-husking had damaged the embryo tip of free grains, a problem also reported by emmer and spelt growers in Asturias (Halstead 2014, 138-139). Damianos first sowed 260 kg of spikelets per hectare, but strong tillering resulted in a dense sward "like a lawn", causing him to try lower sowing rates thereafter. Khristos in Aiginio first tried 200 kg/ha for emmer and the following year reduced this to 150-180 kg/ha for emmer and 165 kg/ha for einkorn. Most informants aimed to sow their glume wheats in autumn, at a similar date to free-threshing wheat, although Damianos was considering a delay in sowing emmer on his richest land to reduce the risk of it growing too tall and lodging (again a tactic widely deployed in Asturias – Halstead 2014, 27). After wet autumn weather, however, Khristos did not sow one emmer crop until early March and Giorgos at Prodomos, western Thessaly, delayed sowing his spelt until "the other wheats were knee-high", but both late sowings produced satisfactory harvests.

As the sown crop was growing, Damianos noted that his emmer smothered weeds and also remained green during a dry May when other local cereals were turning yellow – a result he attributed to emmer's deep roots. At Kasteli in the Mesara lowlands of southern Crete, another Giorgos reported that his 2015 crop of emmer was clean, whereas his fields of barley and free-threshing wheat were full of weeds – one of the latter so much so that he did not even harvest it.

Some informants maintained that emmer ripened at the same time as free-threshing wheat and others that both emmer and spelt ripened a little later, but the glume wheats certainly suffered far less if harvest was delayed by bad weather or unavailability of personnel/machines for reaping. For example, at Ierapetra in southeastern Crete, Andreas' ripe emmer remained intact in the field while the ears of his free-threshing wheat scattered. Likewise, in mid-July 2013 (a month after he had harvested his own crop), Damianos saw a neighbour's stand of emmer unharmed by recent rains across Pieria that would have devastated free-threshing wheat. This resilience can be attributed to the same characteristics of the ear and straw that make de-husking and harvest difficult. Thus Khristos left part of his 2014 emmer crop to be harvested with sickles by his father and uncle, veterans of manual reaping, who reported that the straw was tougher and much shinier (as their neighbours had found several decades earlier in the case of einkorn) than that of free-threshing wheat. Moreover, in the following year, when he gave bales of both emmer and einkorn straw to a friend, the latter's machine was unable to chop the straw as required for use as fodder.

The biggest challenge facing new cultivators of glume wheat has been de-husking of the spikelets, with informants variously resorting to purchase of specialist equipment from Italy or to adaptation of existing equipment, traditional or modern, for threshing or milling rice or other wheats. In several cases, the costs or losses involved were considered prohibitive and led to abandonment of glume wheat cultivation. While trying to sell his crop, however, Giorgos at west Thessalian Prodromos noticed that his stored spelt spikelets were spared damage by insect pests, unlike his free-threshing wheat grain. Zaharias near Peza in central Crete similarly reports that emmer spikelets stored for four years in a large jar are untouched by the pests to which his stored macaroni wheat grain succumbs relatively rapidly.

In addition to experimenting with different sowing rates and de-husking methods, new cultivators of glume wheats have also varied in their application of fertilisers (and, of course, in the prior fertility of their fields). On land not previously under long-term fallow or leguminous meadow, however, Khristos in Pieria reports emmer yields *as spikelets* of 1200 kg/ha without fertiliser in 2014 and of 1750 kg/ha with a very light dressing in 2015, while Zaharias near Peza in central Crete and Andreas in the arid southeast of the island reckoned on harvesting 2200-2500 kg/ha and 1000 kg/ha of spikelets, respectively, without fertiliser.

Turning to the reasons for the recent expansion of glume wheat cultivation in Greece, commercial growers have largely done so in search of a new "niche" crop, while those growing mainly for domestic consumption are usually seeking to improve their own diet, but some shared beliefs or values underpin the behaviour of both groups. First, some members of both groups are aiming for an organic product, exploiting the superior ability of the glume wheats, compared to free-threshing wheats, to grow without chemical fertilisers or weed-killers. Secondly, many small-scale producers, and probably also many customers of their commercial counterparts, are attracted by the reported lower gluten content of the glume wheats, even though most of those so motivated seem to have had no medical diagnosis of gluten intolerance. Thirdly, many small-scale producers are drawn by, and some of their commercial counterparts actively promote, the "heritage" branding of the supposedly ancient wheats.

Particularly interesting, however, is a popular perception in Greece of the glume wheats, and especially emmer, as combining heritage value and health benefits. In its most elaborate form, the argument runs as follows. First, the staple grain of the Classical-era Greeks who created the Parthenon and other iconic cultural masterpieces was, according to ancient written sources, *zea* or *zeia.* Secondly, proponents of this view interpret *zea*/*zeia* as representing emmer (or emmer and spelt) (e.g. Xynias et al 2014) and attribute the physical and intellectual decline of 21st c Greeks to their unhealthy diet dominated by bread wheat, which was supposedly relegated to the role of fodder for horses in antiquity. Thirdly, the present dietary dominance of bread wheat can be traced back to legislation in the 1920s by the Greek parliament that banned the cultivation of glume wheats. And, finally, the fateful legislation was the outcome of an international German or Zionist conspiracy (e.g. https://omadaellinon.blogspot.com/2012/12/blog-post_25.html), executed by the Greek politician Eleftherios Venizelos whose surname (*B*enizelos in Greek), according to the most fanciful versions of this tale, betrays Jewish ancestry.

This ahistorical account, which seems to have originated with G. Ayfantis (2010), a military man lacking both relevant expertise and critical judgement (Sarantakos 2013; Korpetis 2013; Xynias et al 2014), is flawed at every step. Leaving aside Venizelos' family tree, the new legislation "concerning the quality and acidity of flours", published in *Efimeris tis Kyverniseos* on

August 5th 1926, makes no mention of *zea/zeia* or indeed of any named type of wheat, but restricts the production, import and use for human consumption of any flour with a wet gluten content of less than 26% – a threshold that would not have outlawed use of flour from emmer, spelt or einkorn (e.g. Mondini et al 2014; Kohajdová and Karovičová 2008; Belcar et al 2020). On the contrary, given the prevailing conviction at the time that the glume wheats, with the exception of einkorn, were not grown in Greece (Gennadios 1914, 400-401, 878; Xynias et al 2014), the target of this legislation was presumably *free-threshing* wheat of low gluten content. Although glume wheats may have been grown in remote upland villages, unbeknown to early 20th c agronomists and legislators, the suggestion that they were a major dietary staple of Greece prior to 1926 is groundless. Likewise, while the precise meaning of *zea/zeia* in ancient Greek is debated, the suggestion that it was preferred for human consumption over bread wheat, while the latter was relegated to use as fodder, is unfounded. As to the supposed link between a diet of emmer and the building of the Parthenon, the average height of the Greek national team (taller even than the Dutch) that won the 2004 UEFA European Football Championship and the brain drain of educated Greeks during the post-2009 economic crisis suggest that consumption of free-threshing wheat has not yet proved as physically or intellectually debilitating as Ayfantis feared. Nonetheless, Ayfantis' claims are of academic interest and significance in highlighting how uncritically nostalgic appeals to past glories can be a highly effective form of branding and, in this case, have encouraged numerous Greek farmers to take up cultivation of emmer or spelt over the last decade.

26.4 Discussion: lessons for the (pre) history of glume wheats

What light might the early-mid 20th c cultivation of einkorn and early 21st c cultivation of emmer and spelt in Greece shed on prehistoric and early historic exploitation of glume wheats? Reassuringly, the experiences of recent cultivators in Greece in many respects confirm what is known from their counterparts in other regions (e.g. Cappers and Raemaekers 2008, 389 table 2), while also offering valuable complementary detail to the more controlled, but less real-world, data from experimental stations.

Thus, most strikingly, the harvested glume wheats are much more difficult and time-consuming than free-threshing bread and macaroni wheat to prepare for human consumption and, for the same reasons, are far less susceptible to spoiling in long-term storage (in which Greek farmers usually identify insect pests rather than mould as the main hazard). For the latter reason, of course, glume wheats enhanced the security of small-scale, relatively self-sufficient prehistoric economies in which direct storage of local surplus was a key strategy for buffering bad harvests (e.g. Halstead 1989), whereas free-threshing wheat grain was much less bulky to transport and thus offered clear advantages in feeding large urban centres, such as Rome and perhaps Athens, that depended on imported grain (Garnsey 1988; Heinrich 2017).

Recent experience in Greece also confirms that ripe glume wheats are markedly less susceptible than their free-threshing counterparts to shedding seed in the field, thus significantly extending the window for reaping at what has traditionally been the most time-stressed part of the cereal growing calendar. One previously noted (Halstead 2014, 120-121) and important implication of this is that the progressive replacement of glume wheats by free-threshing wheat in the Mediterranean during Classical antiquity will have exacerbated the dependence of increasingly large elite estates on external labour at harvest time. An additional observation by recent Greek practitioners was that straw of einkorn and emmer, at least, was particularly difficult to cut during both reaping and, as also with einkorn in Andalucia in southern Spain and Haute Provence in southern France (Halstead 2014, 141), threshing. That manual reaping was more time-consuming and tiring for glume wheats than free-threshing wheats was apparently not seen as a disincentive to their recent cultivation and was presumably more than offset by their much longer harvesting window, but the inability of threshing *machinery* to chop einkorn and emmer straw finely prevented its use as fodder and contributed to the mid-20th c abandonment of einkorn growing in Pieria. In prehistory, especially in temperate Europe but also in the north Mediterranean where outdoor threshing is at some risk to summer rainfall, the difficulty of comminuting glume wheat straw would have provided an additional incentive (Halstead 2014, 173) to harvest and thresh this separately from the ears – as sometimes apparently occurred in the Neolithic of central Europe (Bogaard 2004, 65-66; Halstead 2014, 117).

As previously reported for einkorn in Haute Provence (Halstead 2014, 28), recent growers of both einkorn and emmer in Greece commented on how strongly these glume wheats tillered, which enabled expenditure of substantially less seed corn than for free-threshing wheats and was also much more effective in suppressing competition from weeds. Pre-mechanised cultivators of emmer and spelt in Garfagnana, northwest Italy, and Asturias, northwest Spain, did hand-weed their crops (Halstead 2014, 236), although light and heavy manuring, respectively, may have introduced an abundance of wild seeds and created a favourable environment for their growth. In addition to the suppression of weeds, einkorn especially is highly commended for its ability to thrive on poor and stony land in northern Greece, as also in Andalucia and Haute Provence (Peña-Chocarro 1996, 133; Halstead 2014, 203, 239-40), while emmer in Pieria was observed to be much more drought resistant than free-threshing wheats.

The tendency to sow einkorn on poor land where free-threshing wheats would fail has doubtless exacerbated its reputation for low productivity, encapsulated in the North Thracian response to the question “What/how are you doing”. This reputation has recently been reinforced by the comparative area yields on experimental plots at Thessaloniki in 2013-14 (Korpetis et al 2014; Amanatidis 2014) of einkorn (ca 800 kg/ha), emmer (ca 1800 kg/ha), spelt (ca 1300 kg/ha) and modern varieties of free-threshing bread (ca 5100 kg/ha) and macaroni wheat (ca 4800 kg/ha). In assessing potential productivity in antiquity, however, it must be borne in mind that only modern free-threshing wheats have been subject to intensive selective breeding for higher area-yields under present-day agricultural conditions (e.g. Bladenopoulos and Korpetis 2014) and that evaluation in terms of seed:yield ratio, perhaps of greater concern than area-yields to early farmers (Halstead 2014, 244), would further reduce the gap in productivity between glume and free-threshing wheats.

An important question here is the extent to which glume wheat yields may be enhanced or impaired by intensive husbandry, including heavy application of manure, such as may have been common in the Neolithic of Greece (Bogaard et al 2013; Halstead and Isaakidou 2020; Vaiglova et al 2021). Recent Pierian farmers sometimes sowed einkorn on good as well as poor land and presumably at least occasionally on manured land, given their concern that this risked excessively tall growth and lodging. Yields of einkorn were less adversely affected by lodging, however, than those of free-threshing wheats. Moreover, the risk of lodging can be mitigated: for example, in upland Asturias, emmer and spelt grown on heavily manured land are sown late and/or harrowed to retard their development (Halstead 2014, 195); and excessively vigorous growth can be checked if lightly grazed in late winter-early spring by sheep or goats (Halstead 2006). Arguably the greatest obstacle to intensive and higher yielding cultivation of einkorn in 20th c northern Greece was that its additional processing costs and modest suitability for culturally dominant leavened bread progressively reduced it to use as food for the poor or fodder, sown on land too infertile for free-threshing wheats. Conversely, emmer and spelt in upland Asturias enjoy a locally symbolic culinary status, not ascribed to bread wheat (Peña-Chocarro 1999, 43-44) and so are still grown on heavily manured gardens in rotation with nutrient-hungry maize and potatoes, producing estimated yields between 1250kg/ha and 2500kg/ha of dehusked grain. Much more lightly manured emmer in Garfagnana is said to have yielded 1100-1500kg/ha of dehusked grain, while yields of unmanured einkorn on very poor land in Haute Provence are estimated at 500-1250kg/ha of dehusked grain (Halstead 2014, 239). That these anecdotal estimates are not unrealistically optimistic is suggested by high emmer yields of 3500 kg/ha dehusked grain achieved experimentally with a high nitrogen dressing in central Italy (Marino et al 2016). These modern yield figures for glume wheats, including both controlled measurements from experimental stations and more or less anecdotal estimates by practitioners, exhibit considerable variability and any attempt to model ancient agricultural production (e.g. Garnsey 1992; Whitelaw 2019; Halstead 2014, 247-248; Halstead and Isaakidou 2020, 86) is greatly influenced by which such figure is adopted. The variability in modern yields obviously reflects differences in species/landraces, climate and husbandry regime, while the last is shaped by a range of practical factors (e.g. community size, scale of cultivation, form of land tenure, access to human and animal labour, availability of manure) but also by the cultural value ascribed to each crop.

The interplay between cultural value and husbandry regime of different cereals and pulses is of particular interest. For the most part, the relative ranking of species across the Mediterranean, as (1) human food (e.g. bread and macaroni wheat), (2) flexible food/fodder (e.g. barley, glume wheats, buckwheat) and (3) animal fodder grains (e.g. oat), matches their intolerance of poor growing conditions. There are some regional variations on this general trend, however, such as the preference for groats made of green barley rather than wheat on southern Greek Kythera (Halstead 2014, 138), for emmer and spelt over bread wheat flour in upland Asturias or for emmer and einkorn over free-threshing wheat groats in northern Turkey (Ertuğ 2004). The preference for glume wheats in Asturias and northern Turkey represents loyalty to tradition, but their cultural value in the former region was enhanced historically by landlords demanding payment in spelt/emmer from their maize- and potato-eating tenants and sharecroppers (García Fernández 1988, 167).

The central place of bread in European and west Asian culinary cultures is sufficiently entrenched that its superiority over other cereal products, and thus of free-threshing over glume wheats, may seem self-evident, but the importance of boiled whole-grain cuisine in east Asia underlines the need to question such an assumption (Fuller and Rowlands 2011). In the Mediterranean, the preference for free-threshing over glume wheats can be traced back to Greco-Roman antiquity when leavened bread enjoyed connotations of urban sophistication, while glume wheat-based gruels were regarded as bucolic (Garnsey 1999, 119-122). While free-threshing wheat significantly lowered transport costs for cities dependent on imported grain, storable and potentially mass-produced bread was, compared to gruels and soups, dramatically less demanding of another scarce resource in large urban settlements – fuel for cooking (Heinrich 2017). The same practical considerations arguably favoured the development of large-scale centralised bakeries in the Near East (Goulder 2010), where expanding urban centres and the progressive displacement of glume by free-threshing wheats can be traced back to the fourth mill BC (Longford 2015). Thus the Greco-Roman and later preference in Europe for bread and free-threshing wheats over groats and glume wheats was partly shaped by the practically-based, urban associations of the former.

For pre-Classical Greece, direct textual evidence for the relative cultural value of different cereals is largely lacking, but stable isotope analyses of ancient crop grains reveal differences in the intensity of their husbandry, that in turn suggest local variability in ranking (Halstead et al this volume). One intriguing regional pattern in the relative abundance of different cereals is the apparent dominance of einkorn through the Neolithic and perhaps Bronze Age in parts of Greek and adjacent Bulgarian Macedonia (Valamoti 2017). In Late Bronze Age storerooms at Assiros Toumba in Central Macedonia, einkorn was stored in much larger quantities and in flimsier containers (baskets and unfired bins rather than ceramic jars) than other cereals and pulses (Wardle 1987, 328). The flimsy containers might be taken to indicate that einkorn was of low value and thus perhaps sown on poor soils, but neither stable carbon isotope values (Wallace et al 2015) and the ecological preferences of associated weeds (Jones 1992) at Assiros Toumba nor stable carbon and nitrogen isotope data from Late Bronze Age Arkhontiko and Toumba Thessalonikis in the same region (Nitsch et al 2017) support low-intensity husbandry. For the Neolithic, although this remarkably resilient and undemanding cereal probably played an important role in securing sufficient staple grains in years of extreme weather, it is even less plausible that its prevalence at multiple sites in fertile locations represents an adaptation to poor soils. Einkorn may instead have been highly regarded for cultural reasons (Valamoti 2017, 182-3). In recent rural communities across the Mediterranean, the elaboration of a diversity of cereal-based foods played a crucial role in bringing some variety to a potentially very dull diet (e.g. Halstead 2012) and the range of different cereals cultivated in the Neolithic would certainly have enhanced the potential for such culinary innovation (cf. Ertuğ 2004). It is also possible that regional cuisine in Neolithic-Bronze Age Macedonia assigned particular value to dishes based on whole grains or groats, for which einkorn is very suitable. Microscopic analysis of the structure of charred food residues (Valamoti et al 2019) should ultimately clarify this suggestion, but, as with contemporary interest in *zea/zeia*, einkorn may simply have acquired a regional cultural biography (perhaps equally fictitious) that accorded particular significance to its consumption.

Finally, while the preceding paragraphs have focussed primarily on the potential "field-to-fork" characteristics of glume wheats, in both practical and cultural terms, the recent resurgence of emmer and spelt cultivation in Greece, initially based on seed-corn imported from other countries, has also highlighted the difficulties faced by farmers in growing unfamiliar crops for which there is no prior *local* knowledge base. Initial experimentation, with sowing of spikelets or free grain at different densities on plots of varying fertility, was of course very short-lived and so, in a prehistoric context, would not have been detectable archaeologically. It does, however, underscore the difficulties that might be faced by early farmers, whether attempting to cultivate unfamiliar, exotic crops or to introduce familiar crops to unfamiliar environments in the course of long-range colonisation.

26.5. Conclusions

The experiences of recent cultivators of einkorn, emmer and spelt in Greece represent a useful addition to the body of real-world information on the practicalities of growing and consuming glume wheats. The information presented here variously replicates or supplements that from other Mediterranean regions, confirming that glume wheats, while substantially more difficult than their free-threshing counterparts to prepare for consumption, are for similar reasons much more resilient to pests in storage. Similarly, ripe glume wheats are also more difficult to reap but dramatically less vulnerable to delayed harvest, with important implications for labour requirements at this time-stressed point in the cereal-growing cycle. As elsewhere, einkorn and emmer at least compete better with weeds, and are more resilient to unfavourable growing conditions, than free-threshing wheats. Consistent with this, early-mid 20th c einkorn was often sown on infertile slopes for use as fodder or food of the poor, but was also sown on richer land and valued by some farmers as an ingredient of leavened bread. Moreover, while generally lower yields are reported for the glume wheats than free-threshing wheats, the difference in output would be greatly reduced in the absence of modern chemical fertilisers and weed-killers and especially so if productivity was measured in terms of seed: yield ratios rather than area-yields. Finally, the recent resurgence in growing of glume wheats strikingly highlights the importance of cultural as well as practical rationales in shaping the relative popularity of different cereal species.

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Chapter 27

Modern research and efforts for the organic restoration of prehistoric wheat in Greece

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Abstract
The East Mediterranean is a hotspot of agricultural biodiversity in Europe and the center of origin for wheat and other basic food crops. Hulled wheat species (einkorn, emmer and spelt) are among the most ancient cereal crops, popular within the region for hundreds of years. At a certain point in history, however, the introduction of higher-yielding, free-threshing wheats caused them to fall into a state of neglect, to such an extent that they have become a relic crop. For social, cultural or simply economic reasons, hulled wheats today are becoming popular once again and an exclusive and fashionable food for consumers. Because of the dynamic growth of niche markets and broad demand for organic products derived from ancient or hulled wheat, organic restoration activities have started based on the conservation of genetic resources and application of evolutionary breeding. In Greece, activities carried out over the last two decades by the AEGILOPS NGO, Plant Breeding and Genetic Resources Institute, Greek Gene Bank, laboratories of universities, and seed savers have contributed to on farm-maintenance under organic farming conditions and practices (organic restoration) of hulled wheat and the creation of a growing niche market.

In this article, the organic restoration case of "Kaploutzas" an old Greek einkorn landrace, is examined and also several multi-sector market-based strategies are proposed for enforcing the necessary dynamic evolutionary processes to maintain hulled wheat and enhance cereal biodiversity before it is lost.

Keywords: *hulled, organic, restoration*

27.1 Introduction
Hulled wheat species (einkorn, emmer and spelt) are among the most ancient cereal crops of the Mediterranean region. These cereals were popular within the region for hundreds of years and long represented a basic food product. At a certain point in history, however, the introduction of higher-yielding, free-threshing wheats caused hulled wheats to fall into a state of neglect, to such an extent that they have become a relic crop (Padulosi et al 1996).

The main characteristic that separates hulled wheats from free-threshing wheats is the persistent enclosing hull. This has major implications for crop processing: where hulled wheats are used for human food the spikelets are generally broken open by some mechanized procedure (D'Antuono 1994; Peña-Chocarro 1996).

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Nowadays, einkorn is mostly grown in Western Turkey, on the Balkan Peninsula, in Italy, Spain, Switzerland, Germany and Austria. Emmer wheat has also been grown in Israel, Jordan, Lebanon, Syria, Turkey and Iran. As far as European countries are concerned, the largest area of cultivation can be found in Italy. Spelt, nowadays, is mostly grown in Central and Western Europe and partly in the USA and Canada as well (Konvalina et al 2013).

27.2 Agronomical and quality characteristics

The fact that hulled wheats are mainly grown in mountainous areas today is not simply a result of their isolation but mainly characteristics like their competitiveness against weeds, efficient root systems and resistance to the most common wheat diseases, giving these wheat species certain advantages over commercial wheat cultivars. Additionally, hulled wheats provide lower but more stable yields level in marginal areas (Stallknecht et al 1997). Therefore, they are very useful in organic farming practice (Megyeri et al 2014). These species are more suitable for unleavened products and although the baking quality is inferior from a conventional point of view (Korpetis et al 2014), they have a lot of specific favourable nutritional characteristics (e.g. high proportion of proteins, a favourable composition of aminoacids and a high proportion of mineral elements) (Megyeri et al 2014); (Stallknecht et al 1997). In the 1990s the increase in interest in natural and organic products led to a rediscovery of hulled wheats. Products made from such wheat species are considered interesting alternatives by small and mid-size producers and specialties with high added value in the market (Konvalina et al 2013).

27.3 Origin – Evolution

Wheat cultivation and human civilization have been evolving together since the first human attempt to produce food during the "Neolithic Revolution", more than 10,000 years ago (Shewry 2009). Archaeobotanical data of the earliest agricultural sites in and near the Fertile Crescent shows that the first domesticated wheat species were einkorn (*Triticum monococcum* L.) and emmer [*Triticum dicoccum* Schrank (Schübl)]. An early and clearly unscientific form of wheat improvement was carried out through selection from among wild wheat relatives (*T. boeoticum* Bois and *T. dicoccoides* Koern. ex Schweinf) growing in the Near East, based primarily on yield and other characteristics like most non-brittle rachis and free-threshing naked kernels (Heun et al 1997; Shewry 2009). Both species were the basic food of the human population until the end of the Bronze Age when naked *Triticum* species became dominant in agricultural lands. Spelt wheat (*Triticum spelta* L.) originated after hybridization between wild species which took place at the very early stages of agriculture. It has no single wild ancestor, and the area and date of its domestication are still unclear (Nesbitt and Samuel 1996).

The 1st mill AD saw the replacement of hulled wheats by free-threshing wheats throughout most of Europe. In some areas hulled wheats continued to be grown, most notably in the case of spelt in southern Germany and northern Switzerland (Rösch et al 1992). Explanations for the decline of hulled wheats fall into three categories: financial reasons, dietary preferences and the introduction of new type of crops and plant species into agriculture systems. However, considered as a whole, the ethnographic and archaeological evidence points to an enormous range of uses: as bread (leavened and unleavened), porridge, gruel, in soup, cracked wheat and beer (Nesbitt and Samuel 1996).

27.4 Hulled wheats in Greece

Greece falls within the broader region of the East Mediterranean and the Near East where the cultivation of many Old World crops originated, including wheat, barley, lentils, olives, and peas. For wheat, archaeobotanical evidence from the earliest Neolithic period in Greece, shows the presence of einkorn, emmer and free threshing wheat. In the context of Hellenic economies, it appears that einkorn wheat was the dominant wheat and the staple crop of those groups while emmer was preferred in other locations in the Mediterranean area (Valamoti and Kotsakis 2007). Only at Late Bronze Age does free-threshing wheat grain occur as a crop. During the classical period, the importance of both barley and the hulled wheats seems to have sharply declined, while free-threshing wheats (of unknown ploidy level) replaced them (Nesbitt and Samuel 1996).

In Greece, from the 2nd c AD until modern times, there is no literature reference of any hulled wheat apart from einkorn. Papadakis (1929), the founder of the Greek Institute of Plant Improvement reported that the only representative of hulled wheat in the country was the diploid cv Kaploutzas (*T. monococcum*) which was cultivated up to the 1970s. Accessions of "Kaploutzas" are kept, under long-term storage conditions in the Gene Bank (Stavropoulos et al 2006).

NGO AEGILOPS recently repatriated Greek einkorn accessions from gene banks around the world and private European collections along with Balkan einkorn and emmer landraces for organic breeding purposes (Koutis et al 2014). It is mentioned that the only existing emmer accession, collected by Vavilov in 1920s and still preserved in the USDA genebank as emmer with a "Greek" origin passport has been also repatriated. Since there is no written or documentary evidence of emmer cultivation in the country in the 20th c, it can be assumed that this particular emmer accession was collected in 1929 in the border area near Turkey and Bulgaria. Alternatively, at the time of Vavilov's expedition (1929), it may have been cultivated for a very short period of time, until the widespread adoption of modern cultivars, by Greek refugees after they had been forced to leave Asia Minor, the Black Sea or Pontus in the early 1920s, where they had been living for millennia and were familiar with hulled wheat (Koutis et al 2017).

27.5 Erosion of cereal diversity

Throughout the centuries, farmers have been the major guardians of cereal genetic diversity by cultivating local cultivars or landraces. However, during the previous century, the development of modern plant breeding and high input monoculture with mechanical cultivation practices, posed a serious threat to agrobiodiversity. Over the last two centuries, landraces have steadily been replaced by new modern cultivars, some of which proved less resilient to pests, diseases and abiotic stresses. This means losing a valuable source of germplasm for meeting the future needs of sustainable agriculture in the context of climate change and the world's long-term food security (Newton et al 2010).

In Italy, cereals have suffered from genetic erosion apart from some landraces of maize, rye and hulled wheats (Lucchin et al 2003). A similar situation prevails in Spain, Portugal, southern France and the Balkans. Albania and Greece have experienced extremely high levels of genetic erosion, as replacement by modern cultivars resulted in the extinction of many landraces (Bennett 1971). For Greece, it is estimated that only 5% of the genetic diversity of wheat landraces remained in cultivation in the last century (Koutsika-Sotiriou et al 2011).

27.6 Organic restoration and breeding

Wheat varieties best adapted to organic production may be taller to compete with weeds, with good early emergence and robustness to produce stable yields under fluctuating weather conditions (Lammerts van Bueren et al 2002). Hulled wheats are becoming more important crops of an expanding organic agriculture sector. On the basis of their agronomic and resistance characteristics, einkorn and emmer, particularly, are ideal low-input crops (Megyeri et al 2014).

Efforts on a European level have contributed to on-farm maintenance of landraces in different regions under organic farming conditions and practices (organic restoration). Recently organic breeding and research programs have focused on underutilized cereal species, such as einkorn, emmer, spelt, and macha wheat in European countries and regions where such species were traditionally used (Kovács 2006). In the case of the re-introduction of forgotten species into modern agriculture it is important to exploit the genetic diversity which still exists in such cereals (Newton et al 2010). In Sweden, the Allkorn project, running since 1995, is a cereal Participatory Plant Breeding project for organic farming. The main aim of this breeding program was not only the conservation of local cultivars but also renewing them for future necessities and use in organic farming all over the country. For this reason, cultivars of *Triticum monococcum*, *T. dicoccum*, *T. spelta*, are selected each year for better adaptation to organic conditions (Larsson 2006).

27.7 Hulled wheat and the "Zea" story-myth in Greece

Historically, Greece is famous for its rich agrobiodiversity, traditional agricultural knowledge and food products related to the Mediterranean diet. These particular dietary habits rely on the regular consumption of plant foods, mainly cereals and pulses, as well as fruit and oil plants, with the grapevine and the olive holding a major position both in culinary practices as well as symbolical ones. Although the Mediterranean diet has advantages and plays a key role in today's longevity model, the new challenges of modern life have changed this diet, obviating people's need for quality nutrition and a journey back to ancestral and heritage preferences.

In Greece, after the green revolution of the 1950s, wheat landraces and old varieties were gradually totally replaced. Currently, the main wheat crop in the country (conventionally and also organically) is durum wheat followed by bread wheat, and the seeds used are only from certified modern cultivars. In addition, it is widely acknowledged that the commercial bread sold on the market today is of inferior quality compared to traditional or homemade bread. Recently, Greek consumers have demanded heritage or ancestral wheat (mainly emmer, einkorn or spelt) and high-quality, organic wheat products with special nutritional value (Koutis 2015).

This trend has been fed by the recently invented story-myth of "ZEA" (an Ancient Greek name for hulled grain or wheat, used in the Classical period) contributing to a misleading public opinion about what a landrace or ancient wheat is and making "ZEA" a fruitful business for farmers, processors, importers or food distributors/ retailers. According to that story-myth "ZEA was emmer or spelt wheat which has its origins in prehistoric Greece and was a dominant food that contributed significantly to Hellenic spirit and culture". Even more than that, according to the same story, "farmers were forced by law to abandon "ZEA" in the early 1920s due to the introduction of modern varieties". Finally, "ZEA" has been presented as a "super food" and a "zero or low gluten source of protein" (Nakou 2017).

The trend was popular in the market to such an extent between 2010 and 2015 that consumers preferred "ZEA" bread over traditional bread from hard or bread wheat landrace varieties or even organic bread. According to market demand, the industrial sector invested in hulled wheat and invited farmers to sign contracts with industrial mills to grow commercial emmer and spelt varieties, most of which were imported from Italy or Germany. No interest arose from the bakery industry and millers for einkorn due to its very low yields and unsuitability for large-scale commercial or industrial bread production in comparison to emmer or spelt.

Conventional emmer and spelt crops started in Greece in early 2010s and grew over the next decade. For the years 2017-2018, Loulis Mills, the largest miller-bakery industry in Greece, grew 340 ha. emmer and 150 ha. spelt wheat on contract which accounted for nearly 50% of its annual on contract wheat crop acreage (Loulis Mills, 2018 Sustainability Report).

27.8 Organic breeding and restoration efforts for hulled wheat in Greece

Over the past hundred years, the efforts of Greek wheat breeders have turned to the development of high-yielding, high quality bread and durum wheat cultivars. In contrast, the diploid einkorn, the tetraploid emmer and the hexaploid spelt did not follow a similar improvement program, since their hulled seeds require additional processing in mills to remove the hull (Korpetis et al 2014). In addition, until the beginning of the 21st c Greece had not carried out systematic work to evaluate and select wheat germplasm (including hulled wheat) most suitable for organic agriculture and climate change (Koutis et al 2014).

Addressing the trend for ancient wheat in the Greek market, organic breeding started in 2013 to restore hulled wheat. The problem was that, due to the dynamics of this new niche market and trend, massive seed imports of commercial emmer and spelt wheat from Italy and Central Europe were evident over the years before this, in order to meet growing consumer demand and the need of farmers in Greece. Simultaneously, ongoing interest was also being developed for the organic production of hulled wheat products. Consequently, the selection of appropriate local varieties of hulled wheat was necessary, which would be expected to respond efficiently to the pedoclimatic conditions of Greece, organic farming and low-input agriculture.

In 2015, a post-doctoral research project, funded by the Ministry of Rural Development and Food and co-funded by the European Research Funding Program 2007-2013, was coordinated by the Hellenic Agricultural Organization – DIMITRA (Institute of Plant Breeding and Genetic Resources) on: *Selection and evaluation of emmer, einkorn and spelt germplasm in Greece for organic farming adaptability and bakery-nutritional quality*. Based on individual plant selection applied in 2012 and 2013 (Koutis et al 2014), traditional material from emmer, einkorn and spelt genotypes from Greece, the Balkans and Central Europe were tested in 2015 for organic adaptation and baking-nutritional value. From the experimentation applied, two einkorn and two emmer varieties were selected with higher protein content, better nutritional characteristics and better yield performance in organic environments, either for direct exploitation in organic farming or for contributing to an effective organic breeding program for hulled wheat in the future (Koutis 2015). An open field demonstration day was organized for participatory selection (Fig. 27.1) and a training manual on hulled wheat crops was published to disseminate research results.

Recently, a breeding program has been started at the Institute of Plant Breeding and Genetic Resources in Greece for the development of new varieties of hulled wheats. The main goal of this new plant breeding program is to create genotypes that can compete with bread and durum wheat, increasing grain yield and quality, but also to create genotypes with hulls that can be easily removed from the grain. The final selections of these materials will be evaluated in both conventional and organic environments (Korpetis E, unpublished data).

27.9 Restoration case: “Kaploutzas” a Greek traditional heritage einkorn variety

Einkorn landrace “Kaploutzas” is the only known and still cultivated Greek landrace (Fig 27.2). It is a spring type wheat, with no vernalization requirements. The landrace is sown in mid-autumn and shows a late flowering (April) and harvest (early July). It is characterized by an amazing resistance to pests, diseases and drought (Stavropoulos et al 1992). Also it shows weed competitiveness, low but stable yields and low input adaptability (Koutis 2015).

Papadakis (1929), mentioned that the einkorn landrace “Kaploutzas” was brought from Anatolia with Greek refugees to Thrace, and from there to Central Macedonia. The landrace was evident as a crop until before WWII but was then abandoned. *T. monococcum* was cultivated on a limited scale in Thrace until the 1930s and in regions of Macedonia until the 1970s. It was also found during a 1981-88 collection expedition launched by the Greek Genebank. Zamanis and colleagues (1988) reported that there was strong evidence that the species was still maintained under cultivation on the small island of Gavdos near the southern coast of Crete, and on some other inaccessible small islands of the Aegean Archipelago.

Collected accessions of landrace “Kaploutzas” are conserved at the Greek Genebank. The landrace was revived by seeds preserved in the Greek Genebank through ecological farming networks in the 1990s mainly in northern Greece (Jaradat et al 1996).

Fig. 27.1 Open field day, 2015.

In 2006 "Kaploutzas" was registered in the extensive catalogue of crops threatened by genetic erosion and funded under Measure 3.8 of Axis 3 of the "Agro-environment measures" of the Rural Development Programme 2000-2006. Subsidies were given from the Ministry of Rural Development and Food to farmers for continuing its cultivation and maintenance.

27.10 AEGILOPS NGO and restoration activities for the "Kaploutzas" einkorn landrace

AEGILOPS NGO (Network for Biodiversity and Ecology in Agriculture), founded in 2004, is supporting on-farm conservation of the landrace "Kaploutzas". AEGILOPS' mission, among others, is *to conserve heritage varieties and traditional agricultural knowledge and to restore landrace varieties into contemporary agricultural practice in ways that benefit the community*. AEGILOPS is supporting a network of organic farmers cultivating the landrace in northern Greece and promoting their quality organic products. Moreover, farmers are encouraged to follow training courses about on-farm conservation and selecting from biodiversity (Seed Schools). Finally, farmers are also invited to join organic participatory breeding schemes conducted to improving agronomic performance and quality of landraces (Vakali and Koutis 2014).

AEGILOPS in July 2014, on its 10th anniversary, organized an open field day under the title: *"ZEA with 100 faces"*. Farmers, millers and consumers were invited to select their own "ZEA" type from a Balkan collection of 120 varieties mostly of emmer and einkorn originating from Italy, Albania, Bulgaria, Greece and Turkey, grown organically for research and demonstration at LOTUS Organic Research Farm, AEGILOPS' headquarters in Volos. An open field discussion was organized featuring archeological evidence and discussing the origin of hulled wheat in Greece along with information on its agronomic and nutritional values. People, familiar with the popular story-myth of "ZEA", started to learn the real truth about hulled wheat's origins, evolution and opportunities as a crop. They were also convinced that hulled wheat should

Fig. 27.2 Einkorn landrace "Kaploutzas".

have a place on farm and plate not as a super food but as a precious biodiversity gift from nature. Selection from the gene pool was mentioned as being crucial in order to obtain suitable varieties to meet farmers' needs and consumers' demands for quality and organic products.

Currently, the number of farmers who cultivate the landrace cv. Kaploutzas has been increased thanks to the provisions and support of seed saving and organic farming movements. The landrace "Kaploutzas" is nowadays cultivated mainly in Central Macedonia (northern Greece) but as a crop has expanded south to other parts of Greece (e.g. the region of Thessaly) and is cultivated in small or medium separated fields for a total of 80-100 hectares by a small number of organic growers.

"Kaploutzas" has a growing local, organic niche market potential due to its special taste, rich dietary properties and limited production. Most of the farmer-members of the AEGILOPS network sell the products directly to organic folk or farmers' markets or by using local distributors. Dehulling and processing is a quite costly task which increases production costs and final prices for end users. Some of the farmers in the central Macedonia region use self-invented dehulling equipment and mill the grain at local traditional water mills around Aridaia in the Municipality of Almopia. While the market for "Kaploutzas" could be expanded, no territorial or quality brand has been adopted until now. AEGILOPS recently launched an online platform to promote farmers' products and their reputation in the market including landrace and hulled wheat products.

In 2018, an application was made by members of the AEGILOPS Network in collaboration with the Greek Genebank (of the Hellenic Agricultural Organization DIMITRA) for the registration of the landrace in the Catalogue of Conservation Varieties, according to the EC Recommendation 2008/62/EU of 20th June 2008 (L 162) aiming to protect "Kaploutzas" from genetic erosion and promote its utilization in less fertile, severe pedoclimatic or low input conditions. Today "Kaploutzas" is registered in the National Catalogue as conservation variety.

27.11 Opportunities for hulled wheat in the future

For social, cultural or simply economic reasons, hulled wheats are becoming popular once again. Today, they are no longer seen as the "food of the poor" as they were in the past. On the contrary, they have become an exclusive and fashionable food for which discerning consumers are ready to pay a higher price than for any other wheat product (Padulosi et al 1996).

In Greece, a recent questionnaire survey on landraces contacted by AEGILOPS NGO indicated that quality is one among the prior criteria for restoration (Koutis K. unpublished data). Another survey contacted in 2019, under the Farmers' Pride project (http://www.farmerspride.eu) funded by the EU Horizon 2020 Framework Programme with the participation of the Hellenic Agricultural Organization-DIMITRA in Greece on farmers' willingness to cultivate and restore heritage wheat, revealed that not just organic but also conventional wheat growers can see market opportunities in the future for growing hulled wheat and wheat landraces under conditions (Ralli P., unpublished data).

The reintroduction of grains into our regional foodshed is exciting and inspiring, however, several obstacles still need to be overcome. Our challenge is to raise the economic, agronomic, social and culinary value of wheat landraces, to equal or exceed that of high-yielding uniform wheat varieties so that farmers today will continue to grow and manage them. Multi-sectoral market-based strategies are needed to restore the dynamic evolutionary processes that maintain landrace diversity before they are lost.

On-farm Conservation: On-farm conservation (Hawkes et al 2002), has an advantage over ex situ methods since it provides a natural laboratory for evolution to continue and help the continued gradual build-up of traits imparting adaptation to specific ecogeographical regions and those matching the requirements of local tribes, communities and populations. New and more adapted types evolve and thus diversity is augmented. Working on on-farm projects and evolutionary breeding strategies (Suneson 1956) that actively explore new approaches is probably the best strategy for ensuring that crop diversity becomes more dynamic and that the evolution of landraces will continue.

Participatory breeding: One area with great potential for agrobiodiversity is the increasing demand for organic production, including the production of cultivars as an integral part of this approach (Wolfe et al 2008). Therefore, social innovation and collective action for decentralized and participatory research are needed. The combination of agroecological models of crop production using variety development methods such as evolutionary (Suneson, 1956) and participatory decentralized plant breeding (Ceccarelli and Grando 2007), appears to be the way forward for ensuring the availability and accessibility of healthy food, increasing agrobiodiversity and continuous adaptation to climate changes.

Market-based strategies for genetic conservation and local food systems: When sales take place directly on the farm, consumers are able to appreciate the contact with the farmers, the beautiful landscape and, obviously, the lower cost of the product. However, small local processing industries also exist that are able to commercialize hulled wheat products for a wider market. This is another important source of value for marginal and low-populated areas. Localization of production and consumption of food should be promoted whenever economically possible, as this is the socio-economic sphere in which landraces can thrive (Hammer and Diederichsen 2009). Therefore bakers, chefs and home cooks need to establish new routines to buy directly from local farmers as much as possible.

Legislation – Policy: As the desire to use landraces becomes more and more apparent in order to achieve greater sustainability, legislative changes are needed to promote the exploitation of their diversity and encourage their use (Newton et al 2010). Apart from the growing of such crops, the processing and marketing of the hulled wheat products must also be ensured (they are usually regional specialties). As an alternative to intensive farming a concept should be supported focused on the use of original and traditional species in each region and state of the EU.

For Greece, provisions set by the Ministry of Rural Development and Food for the conservation of landraces threatened by genetic erosion, registration of local varieties in the National Catalogue of Varieties, organic niche market development and direct financial support to farmers may contribute further to on-farm conservation of cereal landraces and hulled wheat in the future.

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Chapter 28

Acorns as an alternative vital food resource today: an example from Kea Island, Greece

Marcie Mayer

Abstract
Acorns have been a major food resource for certain communities on the planet as they can form an abundant wild food source of delicious and nutritious calories that can be available year-round with proper gathering and storage practices. This paper focuses on present day acorn food gathering and processing on the Aegean island of Kea in Greece. It demonstrates that a small group of 4-5 individuals can, in less than one month, gather and store enough acorn to feed themselves and hundreds of others (a small village) for an entire year, *supplementing* other plant and animal food resources. Based on our experience for the OAKMEAL SME on Kea, acorns can be processed into acorn flour that can provide a reliable food resource for an entire small village. Subsisting on acorns, based on our OAKMEAL observations, requires a small investment in labour and could form an obvious choice rather than a food of desperation. Acorn crops are generally reliable and due to their long storage potential in ambient conditions can provide immediate food security for people living in regions with oak tree species. OAKMEAL is the world's first small enterprise to produce healthy foods from locally produced acorn flour. The methods used by OAKMEAL on Kea island for processing acorns are outlined here to demonstrate the practical possibilities of acorns once their properties have been understood.

Keywords: *Acorn food, acorn processing, Aegean, Quercus ithaburensis, Kea island, OAKMEAL*

28.1 Introduction
Based on ethnographic and archaeobotanical evidence it would be safe to assume that acorns have been consumed by different groups of humans at least for those periods when oak forests were available. Oak trees have been an important part of the landscape of the European, North and South American and Asian continents since the Holocene. These nut-bearing trees have been utilized for food by humans since prehistoric times. A proliferation of acorn shell remains, acorn cotyledons and acorn-processing tools have been found at many archaeological sites and it is now generally understood that acorns have been a staple food for most of human history in areas where oak trees grow (e.g. Mason 1995), so much that the term "age of acorns" has been used for parts of the prehistoric past (Levine 1989). North American indigenous

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1.1 ACORN COLLECTION	2011	2012	2013	2014	2015	2016	2017	2018	2019
Acorns collected (kg)	500	1500	2500	400	2200	2600	4000	2000	3800
Number of workers									
OAKMEAL volunteer team	10	8	4	0	6	4	6	4	4
Number of days gathering	12	12	18	5	16	18	24	10	7
1.2 ACORN LOSSES	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
1.2.1 Oak weevil	20%	15%	5%	10%					
1.2.2 Insect infestation						10%	15%		5%
1.2.3 Feral cat feces			30%						
1.2.4 Mold		10%	10%	5%					20%
1.2.5 Rats/rodents						2%			

Table 28.1 Acorn Gathering Statistics 2011-2019 for Kea Island. The statistics clearly show that we now collect more acorns with fewer people in a shorter time. Early years of collecting had many trials and errors until optimum gathering practices were settled upon.

tribes have an uninterrupted relationship with acorns, that never ceased being considered a food resource (Bainbridge 1986). Acorns from both white and red oaks were an aboriginal staple wherever they occurred in California. During the transition to an agricultural society, acorn processing became less frequent as wheat and other cereal grains were cultivated but it was not altogether abandoned. In most regions, in the recent past, acorn eating became stigmatized as these nuts were collected and stored for feeding pigs and other livestock during the lean winter months (Mason and Nesbitt 2009; Mayer 2019). Eventually, only the poorest people continued eating acorns and there was never any culinary exploration made from this rich ingredient. Acorns were soon associated with primitive existence and poverty.

Many horticulturists over the last 100 years have advocated the development of sweet acorns, that do not need leaching, from easily hybridized oaks (Merriam 1918; Smith 1929). OAKMEAL on Kea in Greece has worked with the locally available acorns from the oak tree *Quercus ithaburensis* subs. *macrolepis*, experimenting and developing a processing sequence for these high in tannin acorns, a sequence that renders these bitter acorns into a novel flour which is a nutritious food resource with important benefits that is gluten-free. On the island of Kea, the oak trees were an important resource exploited mainly for the acorn caps. The trees gained protected status under the Natura 2000 protocol for the conservation of rare and important natural resources throughout the world. As the economy changed the decline in the acorn cap market led to the abandonment of the annual harvest and the gradual disappearance of a large number of acorn trees on the island of Kea.

OAKMEAL has organized the collection, storage and exportation of over 120,000 kilos of acorn caps to be used in the leather tanning industry in Germany, Greece and Turkey. Acorn and acorn cap harvesting could be part of a new localized circular economy that supports current agroforestry systems and forest protection efforts. At the same time OAKMEAL has focused on the processing of acorns, the‘by-products of the acorn caps trade, as a novel, interesting and nutritionally beneficial plant food resource that is seasonally available when acorns ripen and fall off the oak trees, between late September to early December (Table 28.1). This paper offers an overview of the experience acquired by OAKMEAL as regards acorn processing for food, the marketing of acorn-based food products and the prospects of such a food industry for future consumers.

28.2 Oaks and acorns

Across the planet's temperate zones, there are more than 500 different species of *Quercus*, divided into groups commonly known as White Oaks and Red Oaks that are distinguished by both acorn and leaf characteristics. Oak forests are particularly important in view of the high number of flora and fauna present in their forest undergrowth as well as the stabilizing effects on soil erosion. Most of the acorn processing on Kea island has been with *Quercus ithaburensis* subspecies *macrolepis*. On Kea, in the Greek South Aegean, an old growth oak forest covers much of the north eastern and upper ridges of the island from sea-level to 400 meters elevation. Acorns were eaten on Kea in rural areas during the mid-20th c famine and civil war in Greece following WWII. In the past, sweeter trees were identified and cultivated for nuts; many of these trees were spared from the fireplace and still exist today (Mayer 2019). Travel writers from the late 19th c recorded acorn eating as commonly practiced by communities around the entire Mediterranean and Middle Eastern regions (Heldreich 1901). A common misconception by academics, writing about acorn consumption in the 20th

Fig 28.1 *Quercus ithaburensis* growing on Kea island in the Aegean, Greece.

Fig 28.2 Acorn Gathering and Processing Steps adopted by OAKMEAL on Kea Island.

and 21st c, is that acorns with lower tannic acid levels from white oaks are preferable to acorns higher in tannins from red oaks. Acorns from both white and red oaks were an aboriginal staple wherever they occurred in California. However, acorns with higher tannin levels are easier to store in ambient conditions for months and years due to the natural preserving properties of tannic acid (Mason 1995; Mayer 2019). All acorns are edible after the bitter tannins, found in many foods, have been removed. The *Quercus* species has a wide variety of acorns with varying tannin levels, and individual trees within the same species can also vary in tannic levels (Mason 1995). Tannins are easily removed from the acorn nutmeat by soaking in water, boiling, roasting or burying them in the ground.

28.3 Nutritional value/Functional foods

Acorns meet many of the nutrient requirements of humans. They are an aromatic and versatile food ingredient when prepared correctly. Acorns can be stored for very long periods in ambient conditions (Mason 1995; Mayer 2019). Acorns are high in fiber, fats and carbohydrates as well as protein, vitamins and they contain high levels of antioxidant polyphenols and they are a particularly good source of magnesium, potassium and zinc (USDA 2018). The caloric value of acorn varies between species, but ranges between 265 and 520 calories per 100g (Rosenberg 2008). In Turkey, the neuro-protective potential of acorn has been studied by a wide spectrum of scientific departments at Ankara and Aralık Universities resulting in peaked interest for further study (Şenol et al 2018). Acorns processed for food remain high in antioxidant polyphenols which protect against the development of cancers, cardiovascular disease, osteoporosis and neurodegenerative diseases (Fraga et al 2019). Phenolic compounds are also largely known to be very effective in extinguishing free radicals and their regular consumption has been associated with benefits for human health, such as anti-inflammatory and anti-cancer effects (Rakić et al 2006). Additionally, acorns are gluten-free and have up to five times more fiber than wheat or corn.

28.4 Materials and methods

Purposefully low-tech processes have been tested for acorns with two objectives in mind: probability for replication and possibility of scaling-up. Experimentation with gathering and processing acorn by the enterprise OAKMEAL began by studying the practices of the indigenous people of Northern California, who, like so many others around the globe, regarded the acorn as an integral part of their diet. Indigenous people in North America lived and travelled in small groups in which several women were charged with storing and processing acorn throughout the year at campsites along their migratory paths. Acorn was leeched of tannins every two or three days as needed to feed their families. The first challenge was to learn fully the various properties of acorns in order to devise a system for processing and storing large quantities of acorns for later use throughout the year. The Red Oak acorns of *Q. ithaburensis* (Fig 28.1), although higher in tannic acid than White Oak acorns, are easily rendered sweet and palatable through the leaching process (Fig 28.2).

When comparing acorn processing costs to that of current organic cereals, all parameters must be accounted for. After initial expenditures for machines to speed up and partially automate acorn processing, the actual harvest and production costs may be lower than those for corn or wheat, which require intensive planting, cultivation, and harvesting costs for every crop. Acorn trees – oaks - need very little care, if any, interference throughout the year and can be relied upon to have steady yields. Oak trees begin to produce acorns at or near ten years old and may live to be 200 years old. Even a small tree can produce 80-100 kg of acorn nuts or 25-35 kg of processed nutrient-rich flour.

28.4.1 Gathering/Harvesting

Our OAKMEAL experience on the island of Kea shows that locations must be pre-assessed each year for the quality and quantity of the acorn crop. Once acorns have been located and permission to gather has been granted by the owner of the trees, the acorns must be monitored for optimum ripeness upon harvest. Clearing dry grass and brush from under the oak tree makes gathering easier and reduces nut infestation.

Fig. 28.3 The acorns of *Q. ithaburensis* are exceptionally large.

Medium-sized trees on Kea usually yield the largest acorns; larger-sized acorns are preferable for maximum processing efficiency. The particular Kea acorn species is exceptional for its large acorns that can reach 6 cm length (Fig. 28.3). Individual trees have been identified that consistently yield larger acorns which are generally sweeter. On Kea, where the trees are found on private property, the best acorn cultivars are encouraged to be protected although this is in no way guaranteed, despite EU regulations prohibiting the cutting of entire trees (Natura 2000). Acorns are gathered while still green and are left to ripen in the sun to lessen the likelihood of widespread infestation in the tree by acorn weevils (*Curculio*). Acorns are collected by nets that are spread under the trees while the branches are hit in a downward motion with flexible sticks and poles. For maximum efficiency, acorn harvesting requires groups to work together to collect and store enough nuts for at least two years in case there is a rare year when the trees do not bear acorns. On Kea the most efficient gathering group consists of one or two climbers and at least two or three people to separate the acorns from any attached branches and leaves before bagging the nuts for removal. Older people and individuals with mental and/or physical challenges can be very productive under the trees after the acorns have been whacked down. Trees should be swatted at from the interior toward the exterior of the tree canopy to prevent damage to the next years' crop. Most acorns will be found on the side of the tree that receives the most hours of direct sunlight and the least infested nuts are usually at the very top of the trees. Very tall trees can be skirted with nets and acorns are collected days or weeks later after the highest nuts have fallen. Freshly gathered green acorns are laid out on waterproof tarps for a few days until they naturally separate from the large spiky caps. Acorn caps remain on the tarps to dry for exportation to leather tanning facilities in Greece, Germany and Turkey.

Fig. 28.4 Hohenheim dryer used on Kea by OAKMEAL to dry acorns.

28.4.2 Drying

OAKMEAL uses a solar-powered drying table developed by the University of Hohenheim for drying nuts in rural areas with little or no electricity. The table is covered and raised with rodent guards on each leg. Gathered acorns are protected from rats, rain and morning dew on the table as they dehydrate out enough to rattle in their shells (<13% humidity). Acorns that have been thoroughly dried, or cured, will not be susceptible to mildew damage and can be stored in ambient temperatures for several years.

It has been determined that heavy-duty steel mesh troughs would also be an effective way to dry acorns in warm Mediterranean conditions if the nuts are agitated every few days to allow greater airflow. In colder, damper locations, alternative drying methods can be used which might include wood-burning dryers, upright solar dehydrators and conventional dehydrating cupboards used in pasta-making. Drying acorns until ready for storage can take 3-6 weeks in the 20-meter long Hohenheim dryer (Fig. 28.4).

28.4.3 Storing

Cured acorns (i.e. crystalline hard and rattling in the shell) are stored in plastic or wooden vegetable crates. Crates are stacked in a manner that allows air to flow through. If plastic crates are used, unfinished pieces of timber are buried in each crate of acorns to absorb excess humidity that can occur in storage. Large branches of laurel (*Laurus nobilis*) are stacked on top of and around the crates as a natural insect repellent while the nuts are in storage. Mark Nesbitt witnessed acorns from both *Q. brantii* and *Q. boissiere* being eaten as a snack on a fieldwork trip to the southeast regions of Turkey in 1990 and it is known that acorns were regularly stored in these regions until the 1950s; it was also noted that acorns could be stored for 1-2 years (Mason and Nesbitt 2009). OAKMEAL has sampled acorns in storage for 3, 4 and 5 years and we have found that acorns stored un-leached remain a viable food source for five years.

28.4.4 Dehulling and winnowing

Acorns to be prepared for flour are taken out of dry storage and their hard shells are removed by a very large huller/winnower built in Turkey specifically for the large acorns of *Quercus ithaburensis*. Other machines intended for nut shelling (pecan, almond) can be adapted to shell acorns if the acorns are of a comparable size. As acorns begin to gain popularity, more acorn-shelling options have become available. OAKMEAL's sheller/huller can remove the shells from approximately 1000 kg of acorn in less than one hour (Fig. 28.5).

Fig. 28.5 Acorn DeHuller used on Kea by OAKMEAL to dehull acorns after drying.

28.4.5 Sorting

When acorns have been gathered, dried and stored and dehulled properly, there is very little hand-sorting to do. The nuts, now without shells, are laid out on a large sorting table and any nuts that have been adversely affected by infestation or mould are separated and used as poultry and pig food. Flour-grade acorns are either leached immediately or stored in a deep freezer for later use. A stainless steel silo with airlock would be ideal for storing dried, shelled acorn before leaching.

28.4.6 Leaching

Most acorns must go through a leaching process to remove bitter tannins. On Kea, acorns from *Q. ithaburensis* that have ripened on the drying table only need a few days in the leaching vats. Sorted acorns are covered with water in stainless steel vats at a ratio of 1:5 for 48 hours, then sliced or ground and returned to a vat of clean water for an additional 24 hours. Portuguese researchers found that leaching acorns in water to produce starch was not only safer than using chemical extraction but also resulted in the purest starch with higher yields, and concluded that this method was the best since it does not use expensive, flammable and otherwise toxic and hazardous chemicals (Reis Correia and Beirão-da-Costa 2010). On Kea we use a commercial top-loading vegetable grater with slicing discs. Ideally, a much larger vegetable-slicing and dicing machine would further cut processing times for acorns.

28.4.7 Drying

The Hohenheim dryer is also used for drying the freshly leached acorn mash. Wet acorn mash is spread on food-grade screens and placed on the drying table for 2-3 days. Drying times will be longer in cooler climates and a conventional dehydrator also works well for this stage. Finished acorn flour can be stored in airtight jars or bags in a cool place away from direct sunlight for up to two years; it can also be frozen to extend the shelf life even further.

28.4.8 Milling

Unlike traditional methods, OAKMEAL mills the processed acorns as the last step. Milling dried acorn chips into fine flour is done by a large pin mill with steel burrs. Stone grinding acorns was tried and rejected because the acorns heated up too much and became a sticky mess between the stone-grinding burrs. Pin mills and hammer mills are both good for grinding acorn; pin mills take up less room and make less noise during operation.

28.4.9 Storing prepared accorns

Acorns can be stored at various stages throughout processing. How acorns are stored is dictated by their intended use. Freshly leached acorns can be frozen while still wet and make excellent vegan burgers. Leached acorns can be stored after drying in airtight jars or bags to be milled or rehydrated later. And finally, acorn flour is stored in sealed bags. Acorn flour lasts two years if sealed and stored in ambient temperatures with little or no sunlight.

The native American methods documented by McCarthy (as reported by Tushingham and Bettinger 2013) indicate that it took nearly thirty hours from tree to table to prepare 15 kg of acorn with a loss of 50% volume and 60% weight. OAKMEAL's experience has been similar in tree to table ratios with a significant shortening of labor hours through the use of modern machinery. To process 15 kg of acorn, with the help of rudimentary machinery, it now takes less than one tenth of the labor hours as of traditional methods (Fig. 28.6).

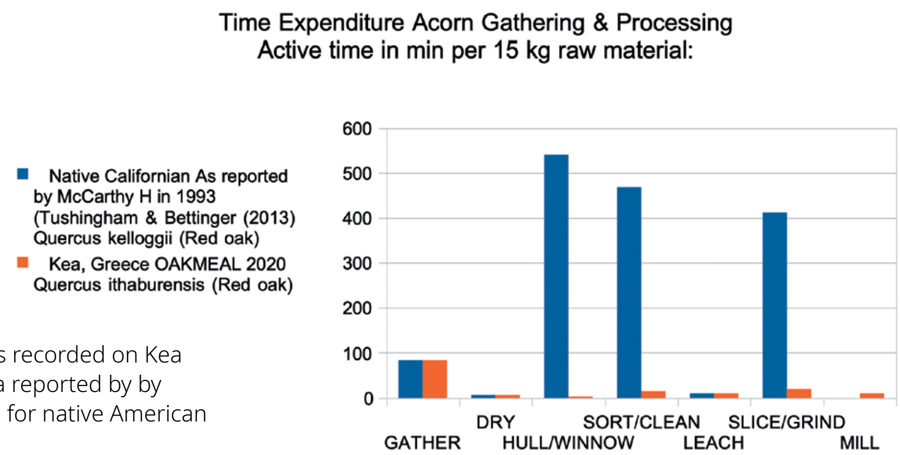

Fig. 28.6 Acorn Processing Times recorded on Kea OAKMEAL and compared to data reported by by Tushingham and Bettinger 2013 for native American methods.

Fig. 28.7 Acorn flour produced by OAKMEAL after the sequence described in Fig. 28.2.

Fig. 28.8 Acorn flour produced and marketed by OAKMEAL.

28.4.10 Cooking with acorn

Acorn can be used as flour or in the coarser "mash" state. Acorn flour does not behave like wheat flour (Fig. 28.7, Fig 28.8). It is gluten-free and therefore contains very little rising agent. Unlike other flours, acorn flour – mixed with liquid (water, juice, milk) and simmered – sets as a jelly. Acorn flour is an excellent thickener for soups and sauces. Acorn flour from *Quercus ithaburensis* is remarkably aromatic with sweet tones of honey and cinnamon. Acorn flour mixed with some cocoa and brown sugar and simmered for 30 seconds with water, milk or nut milk makes a filling breakfast beverage. OAKMEAL has published a guide and cookbook using acorns in new and innovative ways and strives to spread the knowledge that acorns are a functional food ingredient to be utilized for human consumption. A gluten-free study in Portugal found acorn flour to have good technological properties in gluten-free baking, improving bread nutritional and sensory characteristics (Beltrão-Martins et al 2020). Past studies to determine the taste of acorn have relied on the addition of acorn flour to traditional bread recipes in varying percentages and indeed, this is how my experiments with acorn began. It soon became apparent that acorn flour has many more, and better, applications in the kitchen. Recent research in Food Science, however, has covered considerable ground as regards the technological properties of food products containing acorn flour (e.g. Beltrão-Martins et al 2020; Skendi et al 2018).

28.5 Viable by-products from acorn processing

A wide range of products and by-products from the whole acorn harvesting and processing operation chain can be used in various ways, as food, fodder and for leather processing while the potential of substances present in acorns for medicinal and cosmetic purposes are currently investigated. A brief overview of the variable uses of acorns is provided in this section, based on the OAKMEAL enterprise experience on the island of Kea. This overview aims to increase awareness for the importance of acorns as a source of food and other purposes, a trend that is emerging in the last years in other parts of Europe (see for example Papoti et al 2018 for a recent overview; also Sacchelli et al 2021 for a case study in Italy). The OAKMEAL experience in acorn processing offers insights from the perspective of a small enterprise that focuses on acorns as a multifaceted wild plant resource for over a decade; although food is the main interest at OAKMEAL, acorns are marketed for other uses such as their caps while their potential uses in medicinal and cosmetic preparations is also explored for the future. The OAKMEAL acorn products and business experience provides valuable feedback to the recently emerging laboratory-based research on the properties and potential uses of acorns.

28.5.1 Medicinal and cosmetic uses

The medicinal properties of substances in acorns have been researched and their potential may be considerable (see for example Donleavy-Johnston 1995; Karimi and Moradi 2015; Şekeroğlu et al 2017; Şenol et al 2018; Taib et al 2020). One of the by-products generated during acorn processing for food as experienced on the island of Kea by OAKMEAL is a*corn extract. T*he tannin-rich extract byproduct of acorn processing was sent to Kalsec, Kalamazoo, USA for analyses of its contents in order to explore the potential of its commercial use in pharmaceutical and cosmetic applications. This by-product has high levels of Quercetin and Elysium, substances that have been used in these domains.

From the results of a second parallel analysis with the technique UHPLC-Orbitrap-LC-MC, it emerged that the main phenolic constituents of this particular oak extract (*Q. ithaburensis*) are the flavonoid quercetin and the natural antioxidant ellagic acid (PharmaGnose, Halkida, Greece, analysis commissioned by OAKMEAL)

28.5.2 Livestock feed

Shelled acorns that have been damaged by insects, rodents or humidity can be fed to chickens and other livestock. Pigs have the unique ability to spit the harmful shells out and therefore can be fed whole unshelled and unleached acorns, which results in excellent nut-meat (e.g. see Garrido-Varo et al 2019; for livestock feed in California and the Iberian Peninsula see also Vargas et al 2013). Acorn processing leads to a wide array of by-products and possible occupations (Fig. 28.9).

28.5.3 Tanning (acorn caps of Quercus ithaburensis only)

Tannin-rich acorn caps are used in the leather industry for softening, strengthening and waterproofing hides. As industries transition away from polluting chemicals, there should be an increase in interest in acorn caps. Leather, tanned with acorn caps, is a premium luxury product due to its superior quality as reported by the companies that OAMEAL supplies with acorn caps (ARTU in Turkey and Lederfabrik in Germany). Due to this high quality performance of acorn cups in the tanning industry, there is an increasing market interest for this acorn product (Table 28.2) backed up by research in the various extraction methods for the tannins contained in acorn shells (Önem et al 2018).

28.6 Conclusion

Rediscovering the importance of acorns in the past has created new opportunities for this versatile ingredient. Innovative acorn flour and acorn biscuits are now being marketed by a handful of small companies in Greece, Portugal, Switzerland, Germany and California. OAKMEAL has received awards in Belgium, Germany, Paris and Athens for great taste and innovation. In addition to being used in specialty foods, acorns could be a vital ingredient in famine-hit areas and in areas where crops fail due to war and climate events. Storing acorns, with methods that assure the nuts are cured, will extend the time they can be eaten by several years. Since 2011, OAKMEAL has experimented with the best methods for processing acorn that use the least time and energy with premium product results. Each year yields new insights and requires less effort to process more acorns faster and cheaper. There are many different methods for rendering acorns less bitter and ready for cooking; regional weather conditions will ultimately dictate the steps in processing for acorns. In the warm and dry Mediterranean climate, conditions allow for working outdoors and the sun›s energy is used for all drying that occurs during acorn processing. During the research I did for this paper, I found that there is a general misunderstanding that the process of preparing acorns is far too labour intensive for acorn to once again become a common food ingredient. Acorns have frequently been eaten in times of hardship and, together with their principle role as pig food, have suffered stigmatization and subsequent neglect. Despite these obstacles, there is currently renewed interest in acorns as witnessed by an increase

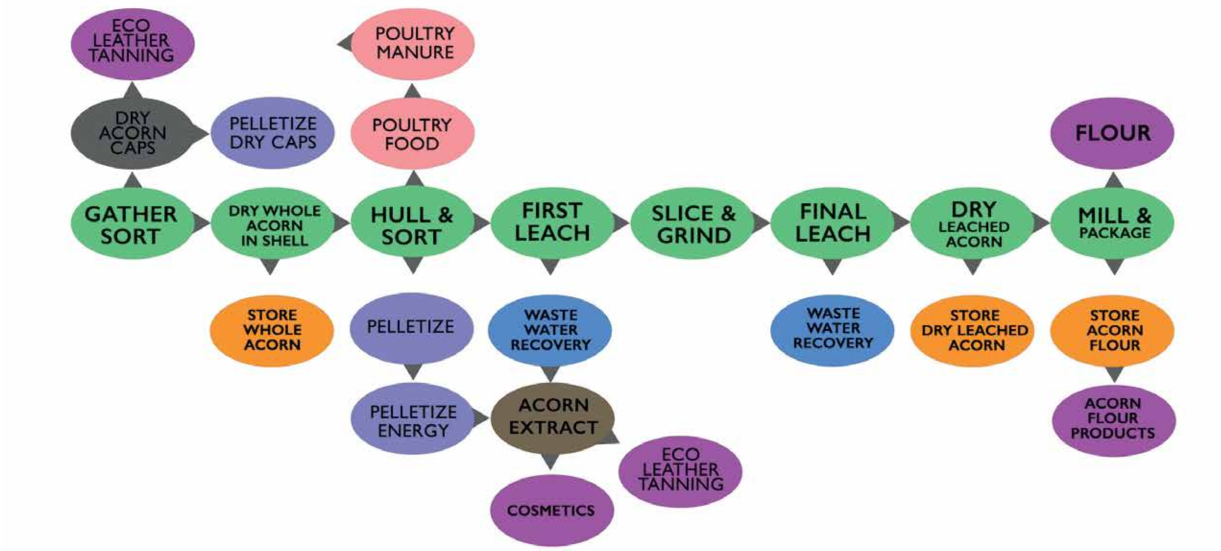

Fig. 28.9 The circular economy for acorns: processing steps from harvesting to end products.

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Exported to leather tanneries (kilos)	4200	30500	600	12000	11500	2000	27000	400	6188
No of gatherers (local farmers)	30	43	0	19	21	0	32	0	12

Table 28.2 Acorn cap exportation figures for the years 2011-2019, indicating quantities of exported caps and number of Kea farmers involved in the process. The figures come from Kea, Greece. The large variation in acorn caps exported reflects the frequency of orders from Germany, Turkey and Greece.

in scientific studies on acorns as well as an expanded presence of acorn-processing information available on the internet. Acorns are an under-exploited resource that can be an important element in our food systems as they are redesigned to meet the circular economy. I hope that the Kea OAKMEAL experience of a small industry specializing in acorns as a food resource paper has contributed towards increasing awareness of this neglected wild tree crop, providing a bottom to top experience with producing and marketing an ancient wild plant food ingredient.

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Chapter 29

Food plants and commensality among early farmers in the Iberian Peninsula: connecting pioneering and modern kitchens

Anna B. Barberà, Sandra Lozano, Ferran Adrià, Ramon Buxó, Antoni Palomo

Abstract

The Neolithic represents a great change in culinary practices, as the introduction and consolidation of domestic plant species and the development of new materials, such as pottery, enabled experimentation with new processes for the preparation and cooking of food. With the arrival of these new edible plants, the specific implements for handling and transforming them also appeared. This implied a change not only in the way of processing food but also in how it was consumed, and this would affect domestic life.

In the Iberian Peninsula, the archaeological record has documented the different stages in the operative chain, from the production and provision of food, including its processing, to its consumption. The site of La Draga, thanks to its outstanding state of conservation, is the source of much of this record.

The new way of understanding the diet, together with innovation in culinary processes, would establish the foundations for contemporary kitchen.

Keywords: *Early Neolithic, plant foods, commensality, culinary processes, modern kitchen*

29.1 Introduction

The introduction of domestic plant species in the Neolithic of the Iberian Peninsula, involved access to an array of products that employed the same techniques to prepare and transform them for consumption. If during the Palaeolithic, the management of plants was characterised by the variety of ingredients and the minimal culinary equipment, in the Neolithic, the system was refined, as places and objects were added to the new culinary trends.

The archaeological evidence is relatively abundant and numerous studies have been carried out in the Iberian Peninsula, albeit with large information gaps in some regions. Nonetheless, the robustness of the data has enabled the determination of the exact characteristics of the objects corresponding to this period: their typology, material composition, uses, etc, and some of the implements needed to make them. It has been possible to establish, in greater or lesser detail, the series of actions required to obtain

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the final product. However, despite determining the implements that may have been used in the processes, it has rarely been possible to identify the place or places where they were carried out. This lack of data especially affects the first stages of vegetable processing.

A second issue is related to the archaeological difficulty in discriminating places used to produce the food. However, two elements that clearly indicate this activity are storage recipients and hearths. Regarding the former, artefacts and techniques associated with the conservation of plant products are known all over the Iberian Peninsula. The latter are normally identified with the domestic area, a synonym of the home and symbolic of commensality, and therefore used to prepare and cook food, among other tasks (Hastorf 2017). In this way, aspects like the shape, characteristics and size of the structure are the main traits distinguishing that use. Not all the hearths would have had the same functions and their use must be interpreted with different approaches. It is consequently important not only to locate the place of the hearth and determine its particularities but also to identify the artefacts that attest the preparation and cooking of dishes.

Neolithic kitchen is at the chronological opposite end to contemporary gastronomy. Yet, both realities are in contact with each other. Among the many things that take place in modern restaurants, we can still find techniques, actions, products and utensils that were created by the first farming communities. Today, crushing herbs in a mortar, baking bread with flour, and cooking a stew with leaves and tubers link us directly with the cooking of vegetables that emerged in the Neolithic. The culinary novelties that these communities developed laid the foundations for cookery practices, both domestic and professional, that are still in use today.

29.2 The Neolithic, a socioeconomic change and a new way to make use of the natural environment

The neolithisation process in the Iberian Peninsula was a historical event of great complexity that cannot easily be reduced to a simple explanation, owing to the different factors that influenced it. The new Neolithic way of life transformed aspects of subsistence, ideology, social relations and the way of relating to the environment (Rojo et al 2012). This process completely changed the culinary activities of the last hunter-gatherers and established the methods of modern traditional cookery.

The different explanatory proposals and models that have been generated to describe neolithisation reflect, among other aspects, the role played by the last hunter-gatherer communities and the great ecological diversity of Iberia, which is by no means a uniform territory. The unequal development of research and theoretical approaches with which the study of the early Neolithic has been addressed is another important factor.

The oldest archaeological data in the Iberian Peninsula frame the advent of the Neolithic and the presence of domestic plant species – cereals and pulses – in about 5650/5500 cal BC (Bernabeu 2009) at settlements on the Mediterranean coast, such as Mas d'Is (Oliva, Valencia) and El Barranquet (Penàguila, Alicante). These are associated with communities that came from Liguria and who brought impressed ware, prior to the classic Cardial groups. The latter were present in the whole littoral area and inland from about 5500-5300 cal BC (Rojo et al 2012).

Five hundred years after these first farming settlements were founded, the whole Iberian Peninsula had received the influence of the Neolithic, expressed in different ways in each area: in Portugal (Carvalho 2003), Andalusia (Ramos et al 2005), Catalonia (Oms 2014), the Duero river basin (Garrido et al 2012), Valencia (Bernabeu 2009) and the Ebro river basin (Alday 1996).

29.3 The management of plants: cultivated and wild species

In the history of plants, some species have gone from being wild to domestic, depending on human manipulation for their propagation, although not all the manipulated or cultivated species can be domesticated, and this relies on genetic features of plant species (Murphy 2007). In the course of their evolution, some of them became key plants in the human diet, while others have been relegated to a secondary role or have practically disappeared. In Iberia, the absence of plants that were quite important in other Mediterranean regions is attributed to the impossibility of conserving them for their reproduction, their inability to adapt to the environment or simply to their inexistence in the Western Mediterranean.

The archaeobotanical record in the Iberian Peninsula has increased significantly in recent years (Peña-Chocarro et al 2018). The available information displays great regional and local diversity in much of the territory, but is especially abundant in Catalonia as a consequence of the carpological finds at the site of La Draga, in Banyoles, Girona (Antolín 2016).

The wide range of crops that have been identified reflect an array of situations that may be the outcome of ecological, cultural or even functional factors, but with the common denominator of a great variety of plant species, including cereals and legumes. In addition, the consumption of wild fruits continued to form a large part of the Neolithic cuisine and diet. In this regard, a wider range of crops has been detected along the Mediterranean coast, in the south of the Iberian Peninsula and in Portugal, where naked wheat and naked barley were combined with legumes, whereas hulled wheat was more common in the interior of Iberia.

The current evidence points to the presence of domestic plants from at least 5550 cal BC onwards (Bernabeu 2006;

Fig. 29.1 Wooden digging sticks and sickles from La Draga (Banyoles, Girona). ©Museu Arqueològic de Banyoles. Author: Salvador Comalat (Palomo et al 2017).

Bernabeu 2009). The rapid expansion of these species is visible in the second half of the 6th mill cal BC, when it can be said that agriculture was widespread across much of Iberia (Peña-Chocarro et al 2018). However, the spread of domestic plants does not seem to be related to or directly connected with the gathering of wild plants in the previous period (Buxó 1997).

Cereals are the most abundant of the domestic crops, and the frequency of the plant category varies between different types of wheat and barley. The former includes both hulled wheat: einkorn (*Triticum monococcum*), emmer (*Triticum dicoccum*) (in some cases the "new glume wheat") and free-threshing wheat forms. The latter are represented by both hulled (*Hordeum vulgare*) and naked barley (*Hordeum vulgare* var. *nudum*). In most areas, naked wheat types (classified as *Triticum durum/aestivum*) and naked barley are the most widely grown.

Great varieties of legumes were cultivated from the start of the Neolithic: broad beans (*Vicia faba*), lentils (*Lens culinaris*), peas (*Pisum sativum*), grass peas/read peas (*Lathyrus sativus/cicera*), bitter vetch (*Vicia ervilia*) and common vetch (*Vicia sativa*). Some other important oil crops in this period were poppy (*Papaver somniferum*) and flax (*Linum usitatissimum*).

Domestic plants were accompanied by a significant number of wild plants that were obtained by gathering as in the previous period and which still represented an important complementary part of Neolithic kitchen in the region (Antolín and Jacomet 2015). A wide range of dry and fleshy fruits have been identified, especially acorns (*Quercus* sp.), hazelnuts (*Corylus avellana*) and pine (*Pinus* sp.) nuts, in addition to others that are more rarely preserved, like grapes, apples and mastic.

All these plants were complementary to numerous wild plants that from the point of view of their consumption offer a range of possibilities, as they may be eaten rapidly and directly, seasonally or throughout the year. These plants of possible or proven consumption, whose fruits or seeds have been identified, include those with edible underground (roots, bulbs, tubers) and/or aerial parts (stems, leaves and flowers). Moreover, some of them might be used as a condiment or in other processes, such as in the making of dairy products.

29.4 Utensils and processes: the main Neolithic innovations

The socioeconomic changes introduced in the Neolithic covered an array of technological innovations that were fundamental in the history of cooking and nutrition. They include both techniques and implements related with the processing of the domestic plants, the cookery elaboration and the transformation of the foodstuffs.

29.4.1 Utensils

Farming tools were represented basically by stone implements, although some examples of the use of wooden tools to prepare the land for crops are known (Fig. 29.1). At the site of La Draga a large number of bipointed wooden objects have been interpreted as digging sticks (López et al 2020a, 2020b). These were generally made with boxwood, although other species, like hazel, oak and Pomoideae, have been found. The analysis of the wear on them shows that they were utilised to work the land. Among the stone tools, no definitive evidence of the use of polished tools (such as hoes) has been found for the Early Neolithic, but in later stages of the period (4th mill cal BC) they are known to have been used in the north-east of the Iberian Peninsula (Masclans et al 2016).

Among the tools used to harvest or reap the cereals, flint sickle elements are abundant at sites from the first moments of neolithisation. Indeed, at that time a major change is seen in the strategies for the management of

Fig. 29.2 Storage basket from La Draga (Banyoles, Girona). ©Museu Arqueològic de Banyoles. Author: Salvador Comalat (Palomo et al 2017).

siliceous rocks to obtain chipped stone tools. Large flint quarrying sites have been documented, for example at Casa Montero in Vicálvaro, Madrid (Consuegra et al 2004). The raw materials for the production of flint blades were obtained in those places and then they were used for different tasks (Palomo 2012), above all cereal harvesting. The flint blades were either used without further preparation or were inserted in wooden shafts, as found at the site of La Draga (Palomo et al 2011), but they were also hafted in other materials, as in the case of the sickle made with a red deer antler found at Costamar in Valencia (Flors et al 2012). Some of the sickles were made with an appendix at the end which allowed the flint blade to be kept away from the ground when the cereals were harvested low down the stem. The flint pieces were held in place with adhesives, such as plant resins, and were arranged in different ways, straight or diagonally to the haft (Ibáñez et al 2008; Palomo et al 2011). The absence of harvesting tools in some regions is attributed to the use of wooden implements, like those that were employed until modern times in the north of the Iberian Peninsula (Ibáñez et al 2008).

Once the cereals and/or legumes had been harvested and processed in different ways, they were stored in containers. The best documented types are silos, which are known all over Iberia and which allowed the conservation of the product in the medium and long term. However, other recipients were used, such as pottery vessels and baskets (Fig. 29.2), like those that have been found at La Draga to store the product (Tarrús 2008). However, baskets could be used for other purposes, such as transportation (which could include harvesting seeds and fruits) (Romero-Brugués et al 2021).

The presence of cultivated plant species is accompanied by the finds of utensils to process them, such as querns and mortars and their mobile parts, the handstones and pestles. Functional studies and the analysis of residues on these types of artefacts have shown that they were used to grind and dehusk different types of cereals. In some cases, as at La Draga, a spatial association has been identified between the plant remains and the processing utensils; those spaces were then interpreted as possible areas specialised in food processing (Alday et al 2014; Herraiz-Batzín 2017).

One of the innovations that came to play a key role in food processing and cookery was pottery. The wide array of ceramic vessels that are found might correspond to diverse functions, including containers that would have been in contact with fire and complements for handling the food away from the hearth (Fig. 29.3).

Pottery is found in the whole of the Iberian Peninsula from the initial phase of neolithisation and the different characteristics that it displays shows that its introduction was not homogeneous. However, a feature that is found on many Iberian products in the Cardial phase is the abundant decoration of all kinds of vessels by the impressions of shells, and the decrease in this decoration in later phases.

The function of the pottery has generally been approached through techno-typological studies that analyse the formal characteristics of the vessels

Fig. 29.3 Pottery vessel with handles from La Draga (Banyoles, Girona). ©Museu Arqueològic de Banyoles. Author: Salvador Comalat (Palomo et al 2017).

Fig. 29.4 Food serving utensils from La Draga (Banyoles, Giorna): a bone spoon; b wooden ladle. ©Museu Arqueològic de Banyoles. Author: Salvador Comalat (Palomo et al 2017).

and their clay fabrics to propose a possible use and relate it with storage or cooking. Large recipients with small mouths have been defined as storage and/or transportation containers, whereas open vessels of different sizes have been interpreted as pots to be put on the fire or as dishes to hold cooked food (Bosch and Tarrús 2011, 58). The few studies of the contents of ceramic recipients have found it difficult to distinguish stored or cooked plant foodstuffs, unlike the case of contents with an animal origin, such as lipids, where the results are much clearer. However, large vessels with carpological remains have been documented: leaves were boiled up in them (Tarifa 2019, 232) possibly to make some kind of stew. In other recipients, remains of resin and wax have been detected; these are usually associated with the production of adhesives (Breu 2019; Tarifa 2019), but a use as food cannot be ruled out (Kashuba et al 2019).

Other utensils connected with cooking are difficult to trace in the archaeological record, although such examples as bone spoons are well-known among Cardial groups on the Mediterranean coast of Iberia (Pascual 1999). Some other wooden utensils are known, like ladles, serving spoons and a whisk, all found at La Draga (Bosch et al 2006) (Fig. 29.4). The latter might have been used to make dairy products, using some kind of plant curdling agent (Antolín 2016). Finds of some plants, like *Silybum marianum* and *Euphorbia helioscopia*, might also be related to that activity in La Draga.

Combustion structures and their connection with culinary activities have still been studied very little (Fernández 2016, 39). Some interpretations have been made through their morphology and association with particular archaeological elements, but without techno-functional studies or residue analyses to obtain precise data about what was cooked and how. In this regard,

Fig. 29.5 Ideal Neolithic scenario to illustrate commensality in la Draga (Banyoles, Spain). Regional Archaeological Museum of Madrid. Scientific authorship: MACB/ CSIC/ UAB/ MAC. Illustrator: Albert Álvarez Marsal (Palomo et al 2018).

structures related with cookery have been inferred though their characteristics: flat hearths, with a floor or a pit full of stones; the latter would have enabled long cooking processes (Fernández 2016, 617-625).

Neolithic cookery takes us directly, for the first time, to the interior of domestic units and daily life. This scenario, which is still seen as a set of relations between people gathering around an activity, is often left in the background of archaeological studies. However, it is important because it was an action that formed part of a custom that may have been repeated during the day, with its fundamental role within consumption: first as an element of social structuring in the domestic unit, through the transmission of concepts based on reiteration; and second, as the essential basis of shared banquets, the symbolism and the structure of which began in models generated by daily consumption, in a framework of common symbols (Fig. 29.5).

29.4.2 Processes

The ways of preparing food have changed over the centuries until reaching what we know today. Despite their simplicity, prehistoric culinary techniques, both Palaeolithic and Neolithic, are the central pillar underpinning the culinary developments in later millennia. The fact that they are still employed, albeit with different tools, is proof of that.

The use of pottery for culinary purposes allowed the introduction and experimentation with new culinary techniques, widening the range of possibilities for the transformation of foodstuffs. Depending on the type of initial processing and the techniques used, the same ingredients can be transformed into a product, or products, with different characteristics in terms of conservation, texture, digestibility, taste or the manipulation of the food itself, among other (Stahl 1989), which widens the options for consumption.

La Draga is one of the sites in north-east Iberia where all these processes have been most clearly detected, from obtaining the foodstuffs to their consumption.

Their exceptional state of preservation, including non-carbonised plant remains and utensils made from perishable materials, has revealed a corpus of data for the whole operative chain (Antolín 2016; Palomo et al 2017; Herraiz-Batzín 2017).

One of the first distinctions that can be made about plant foods is the kind of consumption, either raw or cooked, although some of them need to be cooked or processed to become edible. Eating the vegetables raw would usually be the most immediate and direct way, as it requires little processing or none at all. In contrast, eating cooked food needs a longer preparation time and the use of specialised utensils to manage the intense heat implied by the use of fire.

In the elaboration of foodstuffs, we can differentiate between pre-elaboration and elaboration techniques, these involving the use of fire. Although these cannot always be identified directly in the archaeobotanical record, they can be inferred through other artefacts, like utensils (querns and pottery recipients, for example), combustion structures (hearths), and more specific studies (such as residue analyses of ceramic recipients).

The basic processing technique is milling, which is visible in the archaeological record through querns, mortars, handstones and pestles. With this activity, different kinds of products can be obtained, like semolina (coarse grinding) and flour (fine milling). Cereals and legumes would be the main foodstuffs transformed in this way, but other plants can be ground, such as nuts and acorns and oleaginous seeds, like flax and poppy.

Before milling, however, other pre-elaboration techniques may be related to the processing of domestic plants. First, as the most common treatment, some of the plants, mainly cereals and legumes, may be soaked as a first step to help their cooking and make them more digestible. Second, cereals are dried to enable their long-term storage and conservation, while some fresh foodstuffs (like fruit and mushrooms) may be dehydrated for their conservation over a longer period. At La Draga, masses of fragments of hard wheat grains have been found. These may be associated with the preparation of what is known today as bulgur: a way to prepare wheat that involves parboiling the clean grains, leaving them to dry in the sun and grinding them (Valamoti 2011).

Third, fermentation can transform ingredients to improve their taste and digestibility, eliminate toxic components and shorten cooking times. It is also a way to create new products, such as alcoholic drinks, among others. Ethnography has recorded other preparations of plant foods with this technique for cereals, legumes and dried fruits (Sibbesson 2019). The brewing of alcoholic drinks, similar to what is known today as beer, was documented at the mid-5th mill site of Can Sadurní Cave, in Begues, Barcelona, attested through residue analysis of a fragment of pottery vessel on one hand, and a pestle and a handstone on the other hand (Blasco et al 2006; Edo and Antolín 2016).

Fourth, the toasting of domestic plants involves the use of fire to improve the taste of food, eliminate some poisons (as also by boiling), facilitate the cleaning and dehusking of cereals, crack the shells of dried fruits and also to dry or reduce the water content of some foodstuffs and extend the time they can be kept.

Two main elaboration techniques involve the use of fire: roasting and boiling. The evidence of these techniques is usually identified indirectly through the presence and study of remains such as ceramic vessels with the marks left by the fire or burnt animal remains (Navarrete and Saña 2013).

The first of these is roasting, in which the food is in direct contact with the fire, either suspended over the flames on a spit or on top of or buried below the embers. The latter is a good way to cook roots, bulbs and tubers, for example (Berihuete-Azorín et al 2018).

The second technique is boiling, where the ingredients are cooked in a pottery recipient with a liquid during a longer time. The food can be boiled without any preparation as whole vegetables or processed previously (cut into pieces or in the form of semolina, for example). This technique is the way to make such dishes as soups, pottages and stews, in which a foodstuff is cooked alone or together with other ingredients.

29.5 The connection between the original and contemporary cuisines

In recent years, Spanish gastronomy has made a great effort to enter into a dialogue with other disciplines and construct more complete knowledge about cooking (Adrià and Lozano 2019). Articles like the present one, in which the point of view of professional gastronomy adds new nuances with which to consider the archaeological record, are a good example of this. New ideas can emerge out of the dialogue between culinary professionals and archaeologists. For instance, the new consensus about the definition of cooking: the process through which a raw material is turned into food ready to be eaten, where fire is one option in this process, but is not essential or always a defining factor. What defines cooking is the intention of the cook, that is, the will of transforming a natural product into something more pleasant, more digestible or easier to eat.

From this wider perspective emerges the use of some terms that we are beginning to share. For instance, the distinction between pre-elaboration and elaboration techniques, so crucial in current professional cooking. The first ones refer to all the actions that *prepare* the ingredient to be further processed, such as cleaning, peeling or removing undesired parts, among many others. The second ones consist of the procedures that transform the chemical traits of ingredients to a greater extent, such as boiling, frying, baking, marinating, freezing, drying, fermenting, etc.

The novelties that the Neolithic introduced in the realm of nutrition constitute the second most important landmark in culinary history after the appearance of cooking itself, which occurred in the Palaeolithic. Understanding its details is very valuable for the contemporary gastronomy sector, which needs to reconstruct the genealogy of its main activity, i.e. cooking, to nourish current practices (Adrià and Lozano 2019).

The domestication of plants and all the other Neolithic novelties that accompanied it gave a great impulse to cookery and laid the foundations that still support domestic and professional culinary practices.

Domesticated cereals and pulses led to a large family of elaborations, involving doughs and pastries, and stews respectively, without which the cuisines in most of the world would be unrecognisable. The last hunter-gatherers (Arranz-Otaegui et al 2018) had already discovered the process that Neolithic farmers improved: mixing flour with water, kneading it and heating the resulting dough over a fire or in an oven. Bread is a very intelligent Neolithic product: hence its historical and geographic success. It is one of the most digestive ways of consuming cereals; once dry it can be conserved for a long time, as it only needs to be broken up, grated or rehydrated for it to be eaten without any problems. It is easy to transport and can even be used as a utensil when eating, acting as a spoon, plate or wrapper.

But domestic cereals also opened the door to another large family of products: alcoholic drinks. Neolithic people seem to have appreciated the taste, the thirst-quenching power and altered state of conscience that fermented drinks such as beer, mead and the like enabled (McGovern, 2009): another Neolithic invention that we still have not abandoned (Blasco et al 2006).

The new range of plant ingredients, both domesticated and wild, together with pottery recipients, enabled the cooking of boiled dishes that from that time could be made much more easily than before, in larger quantities and with greater precision. Although the information in the archaeological record is still somewhat limited, they would have had the same ability as today to prepare broths, soups, stews and potages, thanks to a wide diversity of cereals, including hulled and naked wheats and barleys, and legumes, such as peas, lentils, broad beans, vetches and grass peas.

Pottery also enabled two new aspects of gastronomy: conservation and service. Thanks to the sealed nature of the recipients, the difference between cooking for immediate consumption and for storage can be clearly established. Similarly, the array of medium and small-sized recipients was the start of actions that in professional cuisine is called portioning, pouring drinks and plating up, etc; in sum, serving, which at that time began to be carried out in a simple, rudimentary way.

From the perspective of gastronomy, Neolithic cookery possessed all the elements that make it fully recognisable. The products, the techniques and utensils that came available allowed the development of a basic culinary repertoire that is still found in contemporary kitchens.

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Chapter 30

“If you brew it, they will come”: experimental archaeology, ancient alcohol and US museums

Bettina Arnold

Abstract

Archaeologically and historically derived sources of evidence about the cultural evolutionary and socio-economic history of the production and consumption of ancient alcohol have been significantly increased recently by breakthroughs in various areas of scientific analysis. At the same time public interest in craft brews and other forms of culturally enriched alcoholic beverages in west-central Europe and the Americas has resulted in an unprecedented appetite for research-based information about their origins and cultural foundations. This presents an opportunity for archaeologists and historians to partner with researchers in chemistry, agriculture, biology and the brewing industry in developing outreach initiatives whose goals include educating the general public about the disciplines involved in the study of the science and culture of ancient alcohol. The pedagogical potential of partnerships between universities and local museums, breweries and other businesses in the study of ancient alcohol is illustrated by a recent initiative developed in Milwaukee, Wisconsin, also known as Brew City, USA.

Keywords: *ancient alcohol, Iron Age feasting, archaeology of brewing, public archaeology, science education, museum education*

Now more than ever archaeology needs public advocates, intermediaries who can extend the reach of our field beyond the academy to the general public as well as the governmental and private funding sources whose support is vital to the profession. Various institutions apart from the traditional academic outlets such as universities can serve as conduits for the message that archaeology has always had an impact on and continues to make major contributions to contemporary society. To reach beyond the narrow confines of institutions of higher learning such as the one where the conferences and other events on which this volume is based were held or the one where I currently teach we need to find what in advertising is referred to as a “hook”, something that is already of inherent interest to the general public. Judging from the media frenzy that results whenever a scientific journal announces another discovery of the earliest evidence for wine or beer, ancient alcohol is a tailor-made hook of the sort any advertising executive would view as a dream come true.

While there have always been beer-geeks gathering in obscure taverns or someone’s basement to exchange bottles of home brew and pass on the latest esoteric and arcane

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details of a long-lost early medieval recipe for braggot or gruit, the craft brewing movement and the internet have combined to bring these enthusiasts out of their undercrofts and into the limelight. The past ten years have witnessed an unprecedented fascination not only with the beverages themselves but with uncovering the stories and histories behind them. It is here that our opportunity for public education lies. People are primed to be interested in beer and other alcoholic beverages – in fact, according to Robert Dudley and other proponents of the Drunken Monkey Hypothesis, humans have evolved to seek out and consume fermented sugars in nature (Dudley 2014). I suggest that we should use that predisposition to get them interested in archaeology and history and teach them about science and the scientific method in the process.

Because – let's face it – historians and archaeologists, particularly in the United States, which Bruce Trigger described years ago as a country largely uninterested in the past (1981, 1983), don't have a particularly stellar track record when it comes to connecting with the vast majority of the general public whose tax dollars (as we are frequently reminded) support our research. There are many examples of the public perception that both history and archaeology are literally as dry as dust. J.K. Rowling's Hogwarts History of Magic teacher, Cuthbert Binns, is so boring that he is actually dead and the most exciting thing that happens in his class is that he enters it by drifting spectrally through the blackboard. Indiana Jones spends a grand total of two minutes in the classroom in the Indy films, during one of which he writes the terms Neolithic and orthostat on the blackboard, probably the only time most members of the general public will ever see either of those words used in any context. And the less said about Lara Croft and her various avatars, the better. Basically, the implication is that the only way an archaeologist, and by association the profession to which they belong, is ever going to seem exciting is if they are carrying a weapon or wearing hot pants.

The archaeology of beer and other alcoholic beverages, on the other hand, has captured the attention of the public in the last decade in a way that is tailor-made to be used in the service of general education, both about the discipline and about the various scientific and humanistic fields that work in tandem with archaeology and history to literally uncork the past. (Thank you, Dr. Pat!) As Patrick McGovern's work with Dogfish Head Brewery's founder Sam Calagione has demonstrated (2003, 2009), these can be very fruitful collaborations. Thousands of people have by now at least heard of the site of Gordion in Turkey if they have bought a six pack of Midas Touch, the concoction inspired by McGovern's analysis of residue from vessels found in that Iron Age tomb. If they explored a bit further they would also have been introduced to the field of archaeochemistry and how it has been revolutionizing what we know about ancient cultures and their drinking practices.

The venues for outreach and the dissemination of knowledge are numerous and occasionally unexpected. They range from more traditional public lectures sponsored by professional archaeological organizations such as the Archaeological Institute of America to museums large and small. A good example is Brew City MKE, which opened briefly in the downtown Milwaukee Grand Avenue Mall using some of the materials displayed in a very successful exhibit developed by the Milwaukee County Historical Society in 2016. The mission statement of the museum (now unfortunately defunct) was as follows: "As a site of the Milwaukee County Historical Society, Brew City MKE seeks to promote a greater appreciation of Milwaukee County's Brewing History and Heritage, in the hopes of fostering a better understanding of the issues and challenges Milwaukee County faces today." In addition to displaying and interpreting material culture and documentation of the early history of brewing in a largely German city whose identity remains closely linked to the production and consumption of beer, there was an on-site bar serving locally produced beverages. The director actively promoted programming dedicated to public education and attendance was robust due to the ever-changing event schedule. When the building changed hands in 2019 the museum was forced to close but the search for a new location continues.

In 2018 my PhD student Josh Driscoll and I participated in a two-hour public event organized by then-director of Brew City MKE Dana Hansen, now Event and Sales Coordinator for Company Brewing in Milwaukee, entitled "From Ancient Brews to Craft Brews" that included archaeologists and historians as well as cicerone and part-owner of Draft & Vessel Eric Gutbrod as moderator. The bar served the 100+ members of the public who attended a range of alcoholic beverages based on archaeologically and historically attested contexts representing most major continental land masses and several ancient cultures (fig. 30.1). Archaeologist Ryan Williams provided the archaeological backstory of a pepper berry chicha called Wari Ale produced by the Field Museum in collaboration with Off Color Brewing in Chicago. The brew was based on archaeological and botanical evidence from the spectacular 6th c AD pre-Inca site of Cerro Baúl, also known as the Peruvian Masada. Excavations conducted by Chicago Field Museum archaeologists Ryan Williams, Donna Nash and Michael Moseley revealed a 25 hectare site 600 meters above the valley floor, a politically and socially significant outpost of the Wari Empire in the Moquegua Valley on the border of the rival Tiwanaku Empire to the south. The site had obvious ritual and geo-political importance given that water, building supplies and food had to be hauled up to the summit where large structures used for ceremonial feasting were built alongside a massive brewing complex. The entire complex was ultimately destroyed in a final

Fig. 30.1 Participants in the 2018 Brew City MKE event "From Ancient Brews to Craft Brews", Grand Ave. Mall, Milwaukee, WI (photo: Thomas H. Hruby).

ritual of abandonment that involved the smashing of hundreds of ceramic vessels. Nash and Williams based the Off Color brewing beverage, sold in the Field Museum gift shop, on pepper berry dregs discovered at the site as well as chemical residues from storage vessels used in the brewing process. The brewery was capable of pumping out 500-gallon batches of the pepper berry-flavored corn beer, a type of chicha de molle. While the drink may have been consumed by the Wari on a daily basis, it was also used for trade negotiations, to mark calendar events, celebrations, marriages and funerals (Moseley et al 2005). Nash, together with her team and a group of Peruvian women, was able to create a chicha brew with a chemical content very similar to the ancient residues found on excavated vessel fragments. In the process of attending events at which this beverage was served, visitors to the Field Museum were educated not only about pre-Hispanic South America but also about the complex range of beverages consumed by past populations across the globe, not all of which were based on what have come to be regarded as the "traditional" ingredients of beer as defined by the Reinheitsgebot formulated in Bavaria in the 16th c.

Another example of how an archaeological discovery can be used as the starting point for an educational campaign about a little-known (at least in the US) prehistoric culture, in this case pre-Roman Iron Age Europe, is represented by the Landscape of Ancestors project, which I directed together with my colleague Matthew L. Murray of the University of Mississippi (Arnold et al 2000, 2001, 2003). Three field seasons of excavations in two burial mounds near the Heuneburg hillfort in southwest Germany produced a complex mortuary data set of 21 burials, including in one inhumation that contained an unusual curved-handled slashing sword, a helmet crest attachment and a sheet bronze cauldron. The 14 liters of liquid that this vessel originally held were estimated based on the visible fill line and the significant amount of residue was subjected to palynological analysis by Manfred Rösch, whose report is included in the final publication of the excavations (Rösch in press). The results of this analysis indicated that the honey-based beverage the cauldron contained when it was placed in the grave was the product of several hives located in a range of plant biomes and that mint and meadowsweet (fig. 30.2) were likely added as flavorings based on their prevalence in the residue samples. Both of these plants had previously been identified as additives in archaeological contexts in prehistoric temperate Europe analyzed by Hans-Peter Stika (2010), Rösch (2014) and others; meadowsweet in particular is generally considered a likely indicator of the presence of a mead-like beverage. It is worth noting that the analysis of the cauldron contents has so far been limited to pollen residues; additional chemical or proteomic analysis could determine whether or not this vessel contained a MB (mixed beverage) similar to that identified by McGovern (2017, 25-53) in the sheet bronze vessels recovered from the Iron Age tomb at Gordion.

Fig. 30.2 a, b Meadowsweet and mint, pre-hops plant additives found in a 5th c BC bronze cauldron near the Heuneburg hillfort in southwest Germany in 2000 (photo: B. Arnold).

Combining types of alcohol that today tend to be viewed as distinct, such as cider, wine, mead or beer, appears to have been a more common phenomenon in prehistoric Old World contexts than previously assumed and the range of plants involved in flavoring and bittering these brews is also only now beginning to be understood (Rageot et al 2019). Pre-hops plant additives such as meadowsweet, wild carrot, mugwort and bog myrtle that are attested in archaeological contexts (Arnold and Driscoll 2021) and have been identified as possible flavorings/preservatives were therefore the basis for "Ale through the Ages", an educational program developed at Discovery World, a science museum in Milwaukee, by Kevin Cullen, one of my Masters students who is now the Deputy Director and Chief Curator of the Wisconsin Maritime Museum in Manitowoc, WI. The event we organized together in 2012 included the production of Iron Age beverages inspired by the discoveries made at Hochdorf-Reps by Hans-Peter Stika (1996, 2011) and the results of the pollen analysis conducted by Manfred Rösch (in press) on the Speckhau cauldron contents (fig. 30.3). Entitled "Power Drinking and Power Dressing in Iron Age Europe", the event attracted an audience of 70+ members of the Milwaukee public and introduced them to the Iron Age of southwest Germany. Kevin later developed a similar program in Green Bay, where his background in Old World and underwater archaeology informed the Cellar Series program he initiated at the Neville Museum.

Also in 2012 the Undergraduate Certificate in the Science and Culture of Fermentation at the University of Wisconsin-Milwaukee (UWM), where I have been a member of the Anthropology Department since 1996, began as a conversation among a group of faculty members in various schools and colleges about how to train students for careers in brewing and wine production as well as other fermentation industries by combining coursework in the humanities, social sciences and natural sciences. This conversation led to the development of an interdisciplinary curriculum over the next four years, eventually extending beyond the classroom to the UWM Office of Sustainability, where Chief Sustainability Officer Kate Nelson suggested that we consider growing some of the plants used in brewing various kinds of prehistoric and historic alcoholic beverages on campus. She put us in touch with Cindy Anderson, an instructor and PhD candidate in the School of Architecture and Urban Planning, who designed and taught a class in the spring of 2016 in which four teams of architecture students worked with the Fermentation Studies faculty to develop working designs for what was variously referred to as the Hortus

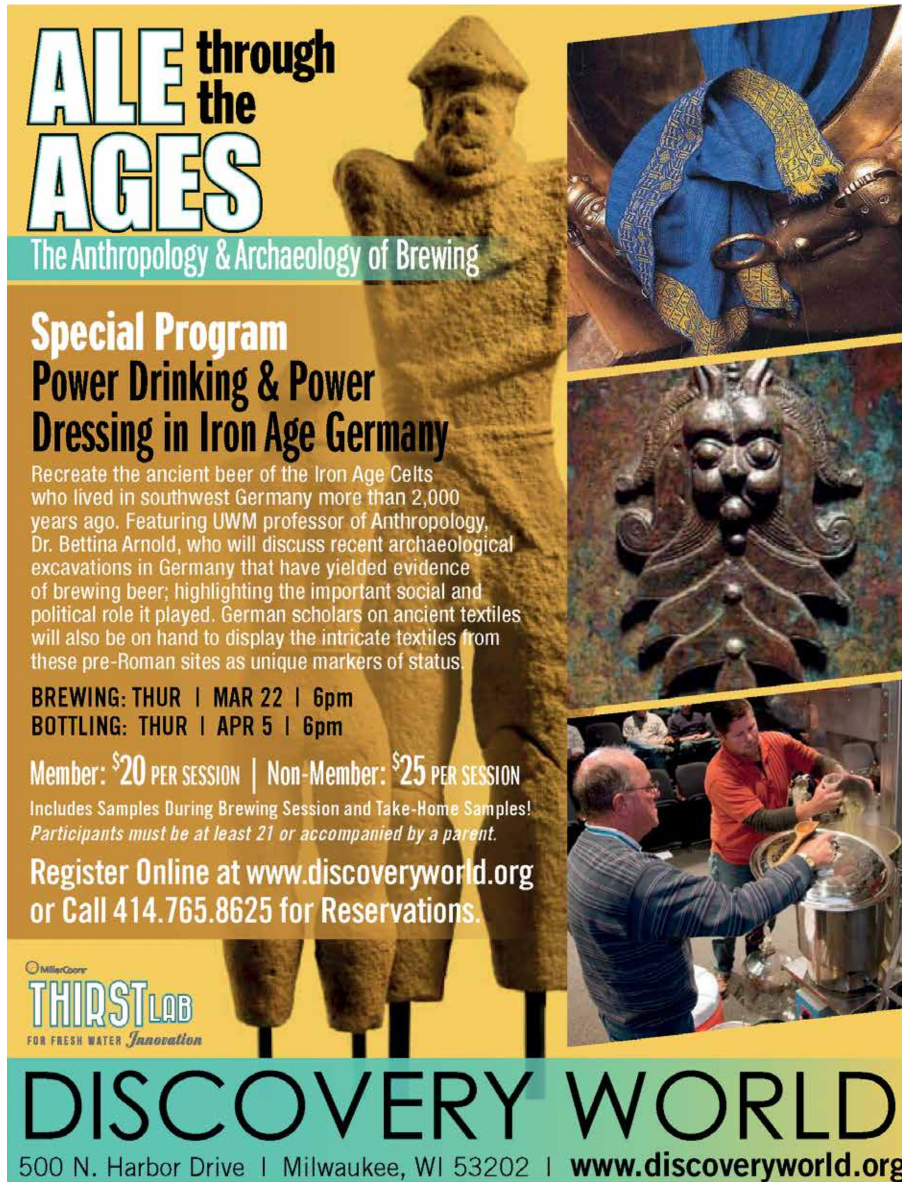

Fig. 30.3 Poster for Discovery World's 2012 "Ale through the Ages" event featuring archaeological evidence from Iron Age Europe (poster: Kevin Cullen).

Academicus or the Brew Garden (fig. 30.4). This has since expanded to include plants used in ancient and medieval textile dying, another PhD project being conducted under my supervision by Michelle LaBerge.

Cindy invited one of the first craft brewers in Wisconsin, owner and founder of Lakefront Brewery Russ Klisch, to come to her class and educate them about how beer and other alcoholic beverages are made. I introduced myself to him after his presentation and later that summer got in touch to suggest brewing a barley-based beverage that contained an equal amount of honey and was flavored with meadowsweet and mint rather than hops based on the results of the Speckhau paleobotanical analysis conducted by Manfred Rösch. Russ was immediately intrigued by the challenge and suggested that Josh Driscoll, who had just entered the PhD program to work with me on a comprehensive assessment of the relative storability of west-central Iron Age European alcoholic beverages (Driscoll this volume), and I should contact Lakefront's Head Cellarman Chad Sheridan, who was a honey-beer, or braggot, brewer in his spare time. We used the original three-barrel system Russ and his brother had started with in 1987 for the rebrew in August 2016 (fig. 30.5). Images, recipes and text can be found on the blog we set up for the Lakefront braggot, which we identified explicitly as an experiment in reproducing the flavorscapes of Iron Age fermented beverages rather than a strict experimental replication of a particular archaeological context (https://sites.uwm.edu/barnold/2016/09/09/braggot-tasting/).

Fig. 30.4 The design for the Hortus Academicus teaching garden at the University of Wisconsin-Milwaukee Honors College (photo: B. Arnold).

The braggot was the focus of an event held on the UWM campus in the Honors College that Russ, Josh and I organized as part of the Wisconsin Science Festival a few months later. Russ brought the braggot we had brewed in August to campus where he participated in the presentation, entitled Power Drinking in Prehistoric Europe, and we served the audience members tastes of this beverage as well as Josh's rebrew of Patrick McGovern's Nordic Grog. The Wisconsin Science Festival event in turn led to a WUWM radio interview for a program called Lake Effect in which Chad Sheridan, Josh Driscoll and I talked about the Speckhau excavations, the archaeological evidence for such beverages in Iron Age Europe and prehistory more generally and how this type of beverage was different from beer today, among other things. WUWM is a subsidiary of National Public Radio, which picked up the interview on its Facebook page and for the next three months there was a media flurry as the concept of a BYOB afterlife, where you bring your booze with you to the next world, introduced the Iron Age Celts to a public audience larger than any we could ever have reached using conventional means. The story even looped back to Germany in the form of a Deutschlandfunk radio interview and an Archäologie in Deutschland short report (Arnold and Driscoll 2017).

Since 2016 we have focused our efforts on developing additional courses and raising awareness of and funds for the Hortus Academicus, which is located on the grounds of the UWM Honors College (luckily for us the Director is a home brewer!). We started with a modest series of

Fig. 30.5 Brewing the braggot based on the bronze cauldron analysis from Speckhau Tumulus 17 Grave 1 (dubbed Keltenbräu #1) at Lakefront Brewery in Milwaukee, WI (photo: B. Arnold).

Fig. 30.6 Groundbreaking ceremony at the Hortus Academicus with University of Wisconsin-Milwaukee faculty, staff and students helping to plant fruit trees (photo: Bonnie Halverson).

plantings focusing on non-hops flavoring and bittering agents such as meadowsweet, mugwort and bog myrtle (the six bog myrtle bushes were donated by the Summer Hill Nursery in Madison, Connecticut and were driven the 978 miles to Milwaukee by Josh Driscoll's father) and then expanded to seven fruit trees used in brewing ciders and perries. The planting ceremony for the two cider apple, two perry pear, one medlar and two service trees was a community effort, with archaeologists from the UWM contract program, administrators from the College of Letters and Science, faculty from Geosciences, Architecture, Anthropology and Pete Sands, the Director

Fig. 30.7 a, b Unhopped Iron Brewer Challenge audience members talking to brewers about their historically and archaeologically informed beverages at the 2019 event (photos: Thomas H. Hruby).

of the Honors College all digging, mulching and watering before tasting beverages produced during the course of the year by members of the Fermentation Studies program (fig. 30.6).

We have been able to use the plants from the garden in the gateway course for the Fermentation Studies program, first taught in spring 2017, as well as in three Unhopped Iron Brewer Challenges, brewing competitions with a pedagogical focus held in December 2017, January 2019 and February 2020 which we organized on campus to bring home brewers and academics together to discuss about how to make the best use of the new discoveries being made in the field of ancient alcohol. The last two winners of the competition, which was judged by the Milwaukee Journal Sentinel's beer reporter Kathy Flanigan, cicerone Eric Gutbrod, representatives of local craft breweries and the home brewing supplier Northern Brewer, had the opportunity to brew a commercially viable version of their unhopped beverage that was launched later the same year at local craft brewery Gathering Place (fig. 30.7a and b). The pandemic put the re-brew of the kvass beverage submitted by Hannah Blija, the 2020 winner, on hold but we plan to organize a fourth event in January 2023.

Fig. 30.8 a The Speckhau braggot being served at the Getty Museum, Los Angeles, CA during their "Bacchus Uncorked" weekend lecture program. (photo: Tomm Carroll); b Santa Monica Brewery Collaboration Braggot (photo: Lisa Guzzetti).

We have plans to gradually expand our program both on campus and in the community, working on developing additional partnerships with craft breweries, hops growers and barley suppliers, as well as organizations like the Pink Boots Society, dedicated to educating people about the prehistoric as well as historic role of women in brewing.

The key take-away points of the utility of archaeological and historical research into ancient alcohol as a mechanism for public outreach and science education can be summarized as follows: Archaeologists would do well to recognize the potential for their results to attract media attention. They should take the lead on reaching out to media outlets and should try to control the story from the outset if possible, placing the emphasis on the archaeological, historical and scientific evidence that is the basis for all experimental re-brews.

Providing good sound bites is one of the best ways to ensure that the journalists focus on the aspects of the research that are of greatest significance. Effective examples I have used in interviews with journalists are catch phrases like "beer and bling" (personal ornament and distribution of alcohol as elite characteristics), "fighting with food" (competitive feasting) and "a BYOB Afterlife" (the extension of socio-political roles in a life beyond death)

It is important to keep in mind that public outreach projects are two-way processes: the public learns from archaeologists but we learn from the public as well. So, seek out partners and allies outside the academy whenever possible; it is easy to make new friends over a re-brewed ancient beer!

Successful collaborations between museums, universities and craft brewers have proliferated since the initial efforts by Anchor Steam Brewing in San Francisco to produce a beer based on the Mesopotamian Hymn to Ninkasi (https://www.anchorbrewing.com/blog/sumerian-beer-project/) in 1989 in collaboration with archaeologists at the Oriental Institute in Chicago. There have been various efforts to brew Mesopotamian style beer since that pioneering effort in the late 1980s. The Oriental Institute of the University of Chicago recently teamed up with Great Lakes Brewing Company in Cleveland, Ohio drawing on written and archaeological evidence and using authentic ingredients, equipment, and techniques to produce a beer called "Enkibru" which has been presented in a side-by-side tasting comparison with "Gilgamash," a companion beer brewed with the same ingredients but made with modern brewing equipment. Other examples include the collaborations already mentioned between the University of Pennsylvania Museum's Patrick McGovern and then-owner of Dogfish Head Brewery Sam Calagione, the Field Museum's production of Wari pepper berry chicha with Off Color Brewery in Chicago, and the braggot rebrew with Lakefront Brewery in Milwaukee based on our excavations near the Heuneburg hillfort in southwest Germany. The Getty Museum in Los Angeles invited me to work with them on a re-brew of the Speckhau braggot in collaboration with Santa Monica Brewery for the Museum's "Bacchus Uncorked" program series in July of 2017 (fig. 30.8a and b) and I was asked in January of 2021 to collaborate with the Heuneburg Museum in Hundersingen, Germany, on a commercially viable beverage based on archaeological evidence from the site and its environs that will be sold in the museum shop. The British Museum in London commissioned and supports a YouTube series entitled "Pleasant Vices" in collaboration with food historian Tasha Marks that explores the cultural backgrounds of various foodstuffs including beer, sugar, chocolate and different aphrodisiacs. Episode 3 focuses on how to make 5,000 year old beer in consultation with brewer Michaela Charles and beverage consultant Susan Boyle. In this case the beer being recreated was based on archaeological and chemical analysis of ancient Egyptian ceramic vessels in the British Museum collections, a good example of how to creatively take visitors on a time-travel tasting trip: https://www.avmcuriosities.com/blog/2018/31/month/pleasant-vices-beer.

For the event at the Getty, one of the goals was to attract visitors who had never been to the museum before and were not interested in wine, the usual focus of the "Bacchus Uncorked" programming at the Villa. One couple I spoke to were second generation immigrants from Mexico and were excited to see beverages being discussed and served that were not part of the Getty's usual focus on the Classical world of Greece and Rome. Such collaborations are a win-win-win for the institutions, breweries and general public who participate in them and the positive feedback provided makes their enduring appeal clear. Following up such events by providing resources for those who would like to delve deeper into the science and culture of alcohol production and consumption in the past creates connections between participant groups that would not otherwise have formed and these can lead to other, unexpected collaborations. A special issue of Archäologie in Deutschland focusing on ancient alcohol published in early 2021 provides additional sources for the academically inclined but links to recipes for aspiring home-brewers eager to try to produce an Iron Age beverage are also included. To sum up, we have an opportunity with the archaeology of ancient alcohol to make effective contact with segments of the general population who might otherwise never read a history book or go to a museum. We should use that opportunity wisely.

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I would like to thank the many UWM faculty and staff, graduate and undergraduate students and local collaborators who have so enthusiastically embraced the project described in this paper. Thanks also are due to the reviewer who pointed out that public archaeology should be a dialogue, not a monologue, a point worth making especially in this era of rampant disinformation. Explaining the basics of the scientific process using ancient fermented beverages as an educational vehicle allows archaeologists to help combat these obscurantist and reactionary forces.

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Dr Julien Vieugué is permanent researcher at the French National Centre for Scientific Research (CNRS, France). His work aims to better understand the evolution of the food habits of human societies during the Neolithic in the Eastern Mediterranean, based on the functional study of Early pottery assemblages in the Near East. In order to identify the actual use of ceramic vessels, he applies an innovative multidisciplinary study method that combines typometry (including shape, size and capacity) and use-wear (including outer soot deposits, inner carbonized residues and abrasions) of Neolithic vessels. Through this unique approach, Julien Vieugué has been able to demonstrate that the earliest pottery in the Southern Levant was used for storing and cooking food, unlike the ones in the Northern Levant. He is currently leading the CERASTONE project (2020-2024) funded by the French National Agency for Research (ANR), one of the objectives of which is to clarify the use of the earliest pottery in the region by analyzing the organic residues (lipids, phytoliths and starches) trapped in the porous walls of Neolithic vessels (see https://cerastone.cnrs.fr).

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Paraskevi Yiouni is an archaeologist working in the Ministry of Culture and Sports, in Greece. She is the Head of the Department of Prehistoric and Classical Antiquities of the Ephorate of Ioannina. Graduate of the University of Ioannina, she took a MA and a PhD Degrees in the Institute of Archaeology, in the University College-London. She supervised rescue excavations in the prefectures of Kavala and Arta and has taken part in the planning of a series of exhibitions in the Archaeological Museum of Ioannina. Currently she is the team leader of the committee for the supervision of the project, funded by the NSRF, "Preservation, Restoration and Promotion of the Theater of Dodona". Her fields of research include material culture and archaeometry, focusing on the production technology and function of Neolithic and Bronze Age pottery from North and NW Greece. She has published articles on prehistoric ceramics and the archaeology of Macedonia and Epirus, in peer reviewed journals and edited volumes.

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COOKING WITH PLANTS
IN ANCIENT EUROPE AND BEYOND

Plants have constituted the basis of human subsistence. This volume focuses on plant food ingredients that were consumed by the members of past societies and on the ways these ingredients were transformed into food. The thirty chapters of this book unfold the story of culinary transformation of cereals, pulses as well as of a wide range of wild and cultivated edible plants.

Regional syntheses provide insights on plant species choices and changes over time and fragments of recipes locked inside amorphous charred masses. Grinding equipment, cooking installations and cooking pots are used to reveal the ancient cooking steps in order to pull together the pieces of a culinary puzzle of the past. From the big picture of spatiotemporal patterns and changes to the micro-imaging of usewear on grinding tool surfaces, the book attempts for the first time a comprehensive and systematic approach to ancient plant food culinary transformation.

Focusing mainly on Europe and the Mediterranean world in prehistory, the book expands to other regions such as South Asia and Latin America and covers a time span from the Palaeolithic to the historic periods. Several of the contributions stem from original research conducted in the context of ERC project PlantCult: Investigating the Plant Food Cultures of Ancient Europe. The book's exploration into ancient cuisines culminates with an investigation of the significance of ethnoarchaeology towards a better understanding of past foodways as well as of the impact of archaeology in shaping modern culinary and consumer trends.

The book will be of interest to archaeologists, food historians, agronomists, botanists as well as the wider public with an interest in ancient cooking.

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