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Fortifying Social Acceptance When Designing Circular Economy Business Models on Biowaste Related Products

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Abstract: (1) Background: VALUEWASTE, a European Commission Horizon 2020 project, is attempting to find new and sustainable sources of protein and fertiliser products using biowaste as a resource. Introducing these products to the market is essential to understand the social acceptance, behavioural changes and socioeconomic impacts related to products and value chains. (2) Methods: The applied framework provides insights from market, socioeconomic, and community acceptance points of view. Initially, we designed the context and targets of the study. The acceptance levels were tested in two study regions: the cities of Murcia (Spain) and Kalundborg (Denmark). Secondly, we established a survey questionnaire (N = 523) combining social acceptance and life-cycle assessment methodology questions. Lastly, we performed a scenario-based workshop discussing behavioural changes related to the introduction of new bio-products to customers. (3) Results: Our study of developing new bio-products (food, feed, fertiliser) from biowaste produced forceful comparative results from the two regions regarding three aspects of social acceptance: market, socioeconomic, and community. (4) Conclusions: The present study, engaging citizens, consumers, producers, and policy makers, provides insights into what is important for the social acceptance of new protein sources for food, feed, and recycled fertilisers from bio-waste in the Murcia and Kalundborg city regions. Our observations, based on analyses applying three dimensions of social acceptance, can be directly applied elsewhere, guiding decision makers on how to fortify social acceptance regarding new circular economy business models and the bioeconomy in Europe.

Keywords: social acceptance; biowaste; business models; insect/bacteria proteins; circular economy; bioeconomy; valorisation; fortification; behavioural change

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1. Introduction

The worldwide population increases exponentially every year and is forecasted to reach over 9 billion by 2050, posing causing great challenges to human sustainability [1,2]. For example, food production will need to increase by 70% to support such a population [3]. Yet, even today, the food system is under pressure. Two key challenges are the increase in demand for food and nutrients and the increase waste output [4], with as much as one third of food being wasted [3]. European challenges are the overuse of natural resources resulting in the loss of bio-diversity, meaning that our food chains are not sustainable [5–7]. To overcome these challenges, circular economy policies provide sustainable solutions and opportunities for companies, customers, and society [8]. The European Union recognises challenges and needs to develop new products from urban biowaste. Thus, systemic change is needed if we are to achieve a circular economy. This means that a whole food chain perspective must be developed, requiring the application of circular bioeconomic (CBE) principles to reduce food waste and losses along the food chain [5,9]. Biowaste is a valuable material for new products and services. However, we lack knowledge on how citizens and businesses will respond to such products. Social considerations related to the implementation of innovations based on the use of waste are extremely complex due to cultural trends and norms, lifestyle, income, diet, social mobility, habits, beliefs, educational level, and access to waste infrastructure [8,10,11]. A lack of knowledge and reluctance to adopt new products limit the implementation of new solutions. One may think of each individual as a nexus of Values, Attitudes, Beliefs, and Behaviours (VABBs). People will change when they can see a good reason to do so and when they feel the relevance of the change; when dealing with large scale change, it is often the behavioural route that is most effective. The issue of how we can shift centre of gravity of the consumption model of individuals and cultures to embrace the concept of the circular economy is a key element in achieving change [12].

This issue has been addressed by the H2020 VALUEWASTE project [13], which proposes an integrated approach to urban biowaste upcycling to produce high-value bioproducts, thereby valorising biowaste in Europe. Value chains valorise urban biowaste side streams as raw materials in order to produce sustainable protein for food and feed products, as well as bio-fertilisers. One of the most important objectives of the VALUEWASTE project is to improve the perception of citizens regarding urban biowaste as a local source of valuable materials. For this purpose, citizens are being addressed through several communication campaigns and citizen and consumer-oriented approaches. The objective is to increase social acceptance and awareness. In this paper, different dimensions of social acceptance are studied relative to the introduction of new products and value chains from biowaste into market. The VALUEWASTE project studies business cases and innovations in three value chains producing food, feed, and fertilisers. The VALUEWASTE project is being developed in two European locations, i.e., the cities of Murcia (Spain) and Kalundborg (Denmark), with the purpose of finding a solution which is technically and socially adapted to different socio-economic contexts. With more than 450,000 inhabitants, Murcia is the capital of the Region of Murcia, a self-governing region located in the southeast of Spain. The city has 460,349 inhabitants and 166,680 families. Males make up 49.0% and females 51.0% of the population; foreigners comprise 12.5% of the population; the average age is 40.7 years, with an average annual variation (2014/2020) of +0.76 [14]. Kalundborg, with a population of 16,490 inhabitants (2017), is located on the north-west coast of the largest Danish island, Zealand. The Kalundborg Region has 48,368 inhabitants and 23,481 families. Males make up 50.3% and females 49.7% of the population; foreigners comprise 5.4% of the population; the average age is 45.1 years, with an average annual variation (2017/2021) of –0.31 [15]. In Murcia, 163 kg of urban biowaste is produced by each resident each year; in Kalundborg, this figure is 57.4 kg (household biowaste only, 2021). Each European citizen produces approximately 230 kg of municipal biowaste per year, resulting in the production of between 118 and 138 million tonnes of biowaste annually in Europe (EU) [16]. Despite the ambitious targets set by the European Commission concerning recycling percentages for different materials, 14 Member States have been identified as at risk of missing the 2020 target of 50% recycling. For these countries, the Commission presents blueprints for action to ensure compliance with EU waste legislation. The actual amount of waste recycled is usually lower than the amount separately collected due to a lack of efficient valorisation technologies [16]. The EU Waste directive states the following targets: 55% of municipal waste to be recycled and prepared for reuse by 2025, 60% by 2030, and 65% by 2035. The most critical waste fraction is the biowaste, representing, on average, more than 45% of the mass of produced municipal waste. However, biowaste can be transformed into green energy, organic fertiliser, feed, biopesticides, bioplastics, and many others bio-based products [16]. Consumer awareness and acceptance of urban biowaste-derived products is helping WALUEWASTE to develop as social initiative. The role of citizens as both producers of biowaste and consumers of biowaste-derived products is essential for the social acceptance and successful implementation of the VALUEWASTE initiative [17,18].

The information generated in the social acceptance studies is being used in the project commercialisation and business model development process. For practical implementation, social acceptance information is needed when developing different aspects of the business model, e.g., regarding customer needs and drivers affecting customer behaviour, customer segments, company solutions. Additionally, it is necessary to provide a comparison with competing solutions in terms of value proposition, marketing channels, customer relationships, key resources, partners, activities, and a revenue model. Notably, value proposition is an important part of Circular Economy (CE) business models. When developing business models, social acceptance is a major evaluation criteria, along with sustainability and business potential.

Very little empirical research focusing on consumer behaviour and willingness to adopt new technologies, products and services has been undertaken, and systematic approaches towards circular economy business models are lacking [19]. Business models describe how an organisation creates, delivers, and captures value in economic, social, cultural, and other contexts. The VALUEWASTE challenge is to optimise the circular economy value proposition of business models by motivating both rational and non-rational consumer behaviour, i.e., routines and individual habits [20]. Also, digital transformation changes consumer values and behaviour, allowing certain business models to prevail. Platform-based, networked business models have gained popularity in terms of CE, in contrast to linear business models (pipes). Thus, digitalisation and technological development as drivers of change of consumer values and behaviour are examples of key aspects that change business models. As such, CE strategies are crucial. The implementation of strategies should include assessments of consumer participation and acceptance of innovation pathways involving all supply chain stakeholders [19].

Target 12.3 of the Sustainable Development Goals agenda calls for countries to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" by 2030. This goal may be achievable if production and consumption practices change [21,22]. Consumer behaviour can be influenced on the basis of command-and-control, market-based, or voluntary change approaches [22]. Consumers are more averse to command-and-control and market-based measures (partly because these are often poorly communicated), making policy makers more inclined to rely on voluntary change. There is little evidence that voluntary behavioural change contributes to significant changes in overall consumer behaviour. Information tools yield responses, albeit on modest scales. This highlights the need to improve carbon literacy levels in the wider population to change social norms. Information tools can be optimised to increase their efficiency by considering the complexity of consumer psychology, including gender norms [22].

Some studies have demonstrated that although consuming insects (as a whole or in powder form) shows significant benefits in terms of protein content [23–25], social acceptance is still very low in Western societies [24,26]. Amato [27] summarised the barriers to insect-based foods in Western societies and potential drivers that might lead to a change in eating habits, providing invaluable information about whether and to what extent consumers would be willing to accept insects (or their components) in their diets, which is crucial for determining how to organise the food chain towards the introduction of insect-based ingredients in Western settings.

The concept of social acceptance dimensions has been used in studies by Wüstenhagen et al., 2007 [28], and Moula et al., 2018 [29]. Related concepts and dimensions are applied in the framework of the present study, including interviews with stakeholders, a survey questionnaire for individuals, and a social acceptance workshop for project stakeholders. Our study evaluates three dimensions of social acceptance, i.e., market, community, and socio-political acceptance [28], using four social indicators: (i) awareness of the biowaste products, (ii) involvement in counteractive measures, (iii) willingness to consume products, and (iv) implementation of socio-political encouragement. The study provides a broad understanding of the potential social reception and describes potential conflicts which may compromise the success of the project, thereby guiding marketing efforts and developing business models for decision-makers. Factors influencing socio-political and community acceptance are increasingly recognised as being important for understanding the apparent contradictions between general public support for new innovations and the realisation of specific projects. The third dimension, market acceptance, has received less attention to date and provides opportunities for further research. Our conclusions can be expected to fortify social acceptance as part of the development of a sustainable business model and are relevant to the application of policy recommendations across Europe.

Information from questionnaires and a workshop was collected to obtain insights and knowledge about social barriers, unmet and unarticulated needs, e.g., pains and gains, barriers and drivers, and perceptions and acceptance on new bio-products. The participation of two contrasting cities (Murcia and Kalundborg) was expected to provide data of interest in our evaluation of biowaste valorisation implementation strategies for those cities.

Our social acceptance study is connected to the social life-cycle assessment (S-LCA) of the VALUEWASTE project, which studies the social impacts of value chains. The task of evaluating consumer acceptance is directly linked to S-LCA, which is made up of different stakeholders, subcategories, and social indicators [30]. One of these stakeholders is the consumer, who is represented via different subcategories, like health and safety, privacy, and feedback mechanisms. Within the latter subcategory, consumer acceptance is a social indicator. In this way, the survey questionnaire on social acceptance formed part of the S-LCA, completing the synergy between the two approaches.

This study seeks to answer the following research questions: what is the social acceptance level, and what importance does that have for the business development of new bio-products (mainly proteins for food and feed and bio-fertilisers) from biowaste (empirical study). Our study combines the three dimensions of social acceptance, providing observations to fortify social acceptance as it relates to circular bioeconomy business development.

The study was expected to provide insights into citizen perception, social acceptance, and awareness of environmental aspects by:

(i). Obtaining insights into the acceptance of citizens, including customers and end users, of new CE products and services related to food, feed protein with insects or bacteria, or bio-fertilisers in relation to the value chains of VALUEWASTE.
(ii). Obtaining insights into consumer willingness to adopt new technologies, products and services.
(iii). Developing and applying systematic approaches when developing CE business models.
(iv). Gaining insights into three aspects of social acceptance when developing a new CE business based on urban biowaste.
(v). Gathering information on changing needs, desires, and demands, which are different in different mindsets and cultures [31].

2. Materials and Methods

Our study framework and the main methods are based on a systematic approach of, firstly, context definition with interviews with stakeholders, secondly, a survey questionnaire for citizens, and, thirdly, a scenario workshop. The results are analysed relative to different dimensions of social acceptance.

In the VALUEWASTE project, the context definition was made during the period of 2018–2019, followed by survey development in 2020 [32]. The survey questionnaire was performed in Spring, 2021 in Murcia and Kalundborg. After a review from the European Commission, an additional survey campaign was undertaken in Spring, 2022 to collect more responses from both regions. The social acceptance workshop was held virtually in February, 2021. The workshop applied a customer behavioural study methodology with a pre-survey and the Prospective Rapid Impact Assessment (PRIA)-methodology to study relevant socioeconomic impacts in a systematic framework for a future scenario [33,34]. (For more detailed information, see the workshop description).

The first step was to define the research context for the social acceptance study, by interviews with key persons and focus groups (VALUEWASTE tasks 8.1 and 8.2). The interviews, focusing on groups, companies, the Murcia and Kalundborg cities, and experts were undertaken between January, 2019 and January, 2020. The stakeholders were categorised as follows: Technology Developers, End Users, Academia, Research Entities, and Public Administration. The interview included the following questions: What are the social characteristics of the application of the technology? Which stakeholders are involved? Who is the investor? Is the initiator an actor from within the community? Is the community invited to participate in the project? Does the local community have significant influence in the process? Which consumer/end user groups will be engaged, and how? Finally, will specific local, tacit knowledge will be used, or is the community only expected to say "yes"? If locals can be involved in either the process or as investors, does this apply to everyone? Moreover, who makes decisions in this regard? Furthermore, we discussed the schedule of the survey questionnaire and the target group(s) and size. The interview also included questions on social acceptance, discussion of social acceptance and different point of views, i.e., socio-political/economical, community, and market acceptance, barriers, opportunities, and who should be targeted by the survey questionnaire on social acceptance. The questions needed to yield information about the VALUEWASTE value chains. The municipalities participating in the survey were asked about the distribution of the questionnaire in city platforms and social media, and ethical considerations and data management (GDPR) were discussed.

Often, portfolio problems are encountered, where the task is to find a set of actions that meets the objectives of the various stakeholders as well as the specific targets (e.g., CO_2 emission reduction) and constraints (e.g., costs). The challenge is that the development and evaluation of portfolios can become very complicated, especially if the number of candidate actions is large and if there are synergies or antagonistic effects among the actions. Portfolio Decision Analysis (PDA) is a powerful approach for dealing with portfolio problems. It is used to develop decision scenarios in each case study area. To support the PRIA phases, the online Into-tool was used [35–37]. Development items were created in a multicriteria evaluation environment, where they can easily and rapidly be evaluated. The tool features PDA analysis based on a core index, and reports according to PRIA zones. The results comprise the portfolio of the most important factors based on the assessments done and the core values calculated using the PDA method.

The results of the workshop are presented in the following PRIA-zones: (1) A protection zone, where threats meet weaknesses; (2) An empowerment zone, where opportunities meet strengths; and finally (3) An innovation zone, where objectives meet actions. The font size indicates the core value of a particular factor; the bigger the font, the more significant it is seen to be by evaluators. In each zone, at least two factors are selected based on the core values. The portfolio is a collection of factors which can be recommended for consideration, both in the design and in decisions about how to improve [33].

In collaboration with the Murcia and Kalundborg municipalities, a structured questionnaire was developed for a campaign on the citizen participatory online platforms of the respective municipalities. The launch of the survey was March–June 2021, and Webropol 3.0 [38] was used to collect the responses. The main purpose of this questionnaire was to measure the public level of acceptance of the three value chains producing new biowaste-valorising products and services or technologies [29]. Specifically, the goal of the survey questionnaire was to assess the public's opinion and knowledge about the use of biowaste side-streams as sources of feed or food protein, or recycled fertiliser. The intention was also to determine consumer motivation regarding improved, separate collection of biowaste, which is crucial for the successful implementation of VALUEWASTE products.

The scope and content of the questionnaire was developed with both participating municipalities and the Project Innovation Team. The three perspectives (social, community, and market) were considered when implementing innovations or a new product innovation process (Table 1):

- Socio-political perspective: to measure respondents' knowledge, awareness, and perceptions about European Union policies, such as greenhouse gas emissions/carbon neutral 2050 policies.
- Community perspective: to study respondents' opinions about the importance of environmental and socio-economic issues, as well as community needs, e.g., new protein and fertiliser sources.
- Market perspective: to study willingness to purchase new products based on insect, bacteria, fertiliser value chains.

Table 1. The Social Acceptance dimensions, adapted from [28], and with additions from the VALUE-WASTE interviews.

Socio-Political Acceptance	Community Acceptance	Market Acceptance
-Of technologies and policies -By the public -By key stakeholders -By policy makers	-Procedural justice -Distributional justice -Trust	-Consumers -Investors -Intra-firm -Supermarket chains -Retailers -Companies selling the products (feed, fertilisers, or pesticides) to the agricultural sector

Thus, the study questionnaire included four parts. The purpose of part one was to gather background information about the interviewee, such as country of residence, age, educational level, and gender. This was to make sure that we obtained information from a variety of people, and to make the information useful in our analysis of social acceptance by different groups of people.

The survey questionnaire had 17 main questions, as well as structured and background information questions (for a more detailed description, see the Analysis of survey data). It was designed such that there would be no correct or incorrect answers. Differences in answers merely reflected personal viewpoint and experience. The first quantitative analysis was made by summarising all the data and calculating the percentage of the choices for each question. In terms of participants, the aim was to include people from different backgrounds to enrich the sample space, and therefore, to make the research results more substantial, reliable, and objective [39].

As an activity involving the participation of humans, ethics committee approval, informed consent, and the protection of personal data were envisaged in our project reports (VALUEWASTE 2018: Protection of Personal Data (POPD) and D11.2 and Human (H) participation D11.4), and all relevant GDPR legislation of the European Union was adhered to when interviewing stakeholders or throughout the survey questionnaire process. The VALUEWASTE project Ethics Management leader ensured that the activity complied with ethics requirements. The acquisition and processing of data complied with the EU General Data Protection Regulation (GDPR). The procedure included the appointment of a project Data Protection Officer (DPO), provided information about how all of the data would be processed, i.e., limited to the purposes of the research project (in accordance with the 'data minimisation' principle), described the technical and organisational measures which were implemented to safeguard the rights and freedoms of the data subjects/research participants, as well as the security measures that were implemented to prevent unauthorised access to personal data, the tools used for data processing, and the anonymisation/pseudonymisation techniques implemented. An informed consent protocol was used. Specifically, this reports provides details on the procedures and criteria that were used to identify/recruit research participants and templates of the informed consent forms, paying specific attention to children and the elderly.

2.1. Analysis of Survey Data

A first analysis was made with the scales for answering Yes/No or a five-point Likert Scale, from (1) Strongly disagree to (5) Strongly agree, which was used when determining public acceptance. Such a scale cannot be directly used to derive the social acceptance levels [40–43], but it can give an indication of whether acceptance comprises withdrawal, approval, or psychological identification, as reported in the VALUEWASTE project reports [44,45].

Initially, there were over a hundred of questions in the survey questionnaire. However, this was reduced to 70. In total, 523 responses were collected from 15 countries, where Denmark and Spain, the target countries, yielded 219 and 254 responses, respectively. The remainder comprised invalid responses for our analyses. The survey included 62 choice questions with three types of answers. The first provided a choice between "Yes" or "No", while the two others were based on a five-point Likert Scale, providing choices between "Agree" and "Disagree", and "Important" and "Not important". Choice questions represented ordinal variables between questions 8 and 69, and 4 nominal variables, between questions 1 and 7, including two countries of residence and two genders (Figure 1), four levels of education (elementary, technical/vocational, Bachelor, and Master's degrees), and five age groups (younger than 18 years, between 18 and 30 years, between 31 and 45 years, between 46 and 65 years, and older than 65 years old) (Figure 2). Questions addressed four social indicators: (i) awareness, (ii) willingness, (iii) encouragement, and (iv) valuing. These factors determine levels of importance for customers, allowing researchers to identify subjects that customers value more, to obtain a typical portrait of a customer, and to determine if customers are ready to buy new bio-products.

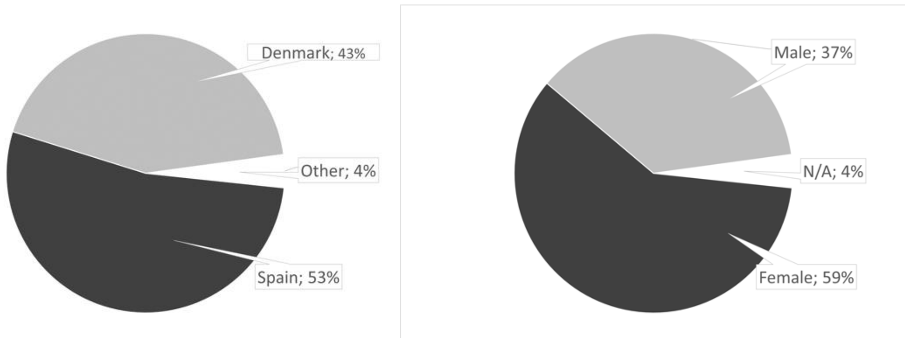

Figure 1. Nominal parameters of the survey questionnaire: Residence and Gender.

The scoring system, which helped us to monitor and measure quantitative data from the survey questionnaire, comprised a data-driven method proposed for social life-cycle assessments [46]. We deployed five-scale Likert-type questions to transform respondents' qualitative information into quantitative data by assigning real numbers to responses which were aggregated into a scoring system. Number 1 was assigned to the lowest social performance, i.e., "fully disagree" or "not important at all". "Fully agree" and "very high importance" were assigned to 5. Meanwhile, questions that provided only two options, i.e., "Yes" and "No", were assigned 1 to "No", and 5 to "Yes". The scoring system was then set out in tables. Quantitative data tables are best visualised and interpreted by colouring [47]; this method utilised the school-type colour scheme, where lower values tend to red, neutral values to yellow, and higher values to green. This method helps identify hotspots from data tables efficiently and is described in detail in the VALUEWASTE project Deliverable 8.4. [45].

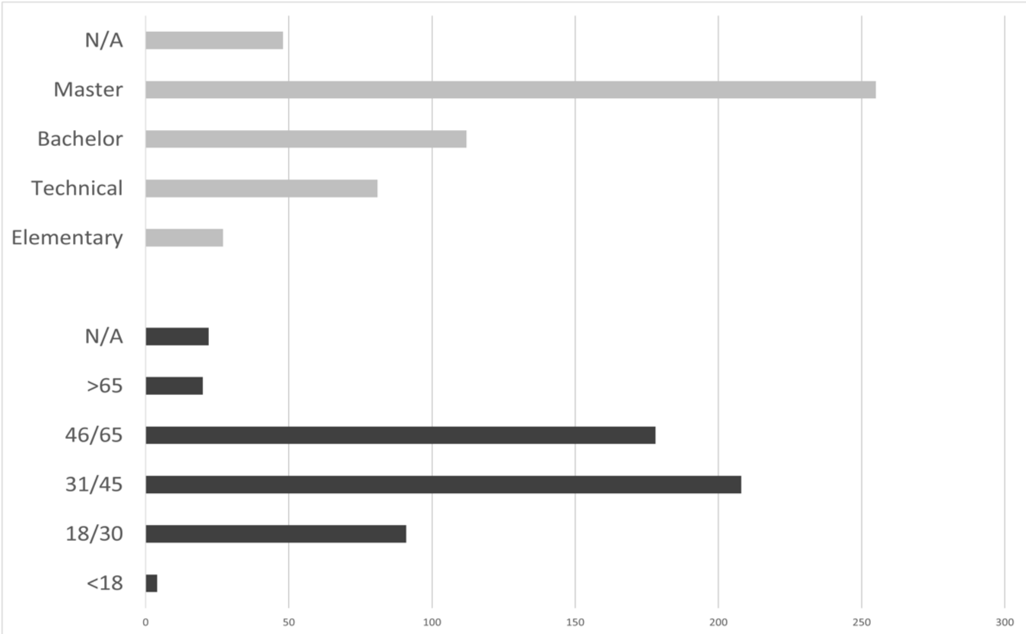

Figure 2. Nominal parameters of the survey questionnaire: Education and Age.

This study deployed a statistical software solution to measure social acceptance. Social acceptance cannot be measured directly [48], i.e., one cannot just ask whether an individual is willing to accept an idea or trend? Moreover, it is not even possible to measure responses for such questions. Therefore, social acceptance should be measured as a latent factor, i.e., a dominant factor that comprises factors that can be measured. Social acceptance is a latent factor that can be generally characterised by several basic factors, like awareness, willingness, motivation, experience, and many others. It is possible to measure and analyse these factors.

Measurements of social acceptance in every specific sphere require explicit research to establish analysis procedures. A set of such hypotheses in the form of supporting questions helped to explain relevant issues. The supporting questions (Appendix A) helped us to be more specific in explaining results of each analysis. It is good practice to ask supporting questions at every step of an analysis. These questions play a dual role; first, they create a logical ladder, supporting the research question; and second, they facilitate the interpretation of each test result that we extract from a statistical software program.

The social acceptance of new biowaste-based products requires the identification of key parameters. Statistical approaches offer a set of tools to examine the dimensions and find relationships and dependencies, to make predictions, and to measure these parameters. Our survey questionnaire was adapted for the Jamovi [49] statistical software program, a compelling alternative to costly statistical products such as SPSS and SAS.

We deployed an exploratory factor analysis (EFA), seeking to identify latent factors explaining the shared variance in the data, a reliability analysis (RA) to measure the strengths of these factors, a Student's *t*-test (*t*-test) to define and measure differences between genders and in the two countries, an analysis of variance test (ANOVA) to define and measure influences among age groups and education levels, and finally, linear regressions analysis (LRA) to define and measure the independent effects of statistically sufficient parameters on dependent factors.

EFA is used to reduce data to a smaller set of summary variables and to explore the underlying theoretical structure of the phenomenon in question. It helps to find the most correlated variables that can create groups of factors and identify the structure of the relationship between the variables and the respondents. Not all variables can describe the groups of factors; such variables are considered unusable. On the other hand, some variables may describe more than one group of factors and so may be useful for several groups. A supporting question for interpreting an EFA can be: are there groups of factors that explain the shared variance in the data? We are interested in the following results of our EFA: checking the sustainability of the correlation matrix by applying Bartlett's test of sphericity (Bartlett's) and "Kaiser-Meyer-Olkin test" (KMO), with both measures sampling the adequacy of each variable in the factor and for the complete factor [50]. Bartlett's $p < 0.001$ and KMO Overall MSA around 0.9 would mean a high level of quality in terms of a correlational structure.

RA is used to define the solidity of every group or factor; it is created by exploratory analyses. RA tests the reliability of a group of variables and its suitability for further analyses. We also created the mean score of each factor after RA had been performed. RA includes two tests: a coefficient-alpha, also knows and Cronbach's α (alpha), and an alternative coefficient McDonald's ω (omega). These tests confirm that variables not only represent separate factors but also that they are internally consistent, meaning that variables describing factors are measuring the same thing in the same way with a sufficient level of dependency [51]. The principle of interpreting alpha and omega coefficients is simple: the higher the values, the greater the internal consistency or the reliability. Coefficients range between 0 and 1 and can be interpreted as follows: $\alpha < 0.5$—unacceptable; $0.5 < \alpha < 0.6$—poor; $0.6 < \alpha < 0.7$—questionable; $0.7 < \alpha < 0.8$—acceptable; $0.8 < \alpha < 0.9$—good; and $\alpha > 0.9$—excellent [52].

t-test, or the "Student's *t*-test", is used to determine the means of two sets of data that significantly differ from one another. The main assumptions for executing a *t*-test are independent observations, ordinal scale, equal variances within groups, and normal distribution [53]. We applied a *t*-test to determine the differences between genders and between the residents of the two study countries. A supporting question for this analysis was: is there a difference in gender or country of residence in any determined factor? Once a sufficient difference has been determined, it may be measured. In these tests, we had to ensure the normality of the dispersion while being not extremely conservative. We were interested in statistical significance, i.e., $p < 0.001$, and the effect size, or "Cohen's d", as shown in Table 2.

Table 2. Interpretation of Cohen's d effect size.

Cohen' Standard	d	r^2	%
	2.0	0.500	50.00
	1.9	0.474	47.40
	1.8	0.448	44.80
	1.7	0.419	41.90
	1.6	0.390	39.00
	1.5	0.360	36.00
	1.4	0.329	32.90
	1.3	0.297	29.70
	1.2	0.265	26.50
	1.1	0.232	23.20
	1.0	0.200	20.00
	0.9	0.168	16.80
Large	0.8	0.138	13.80
	0.7	0.109	10.90
	0.6	0.083	8.30
Medium	0.5	0.059	5.90
	0.4	0.038	3.80
	0.3	0.022	2.20
Small	0.2	0.010	1.00
	0.1	0.002	0.20
	0.0	0.000	0.00

ANOVA is used to determine the differences among more than two means [54]. Education level and age in our questionnaire represented such a case. With the help of ANOVA, we determined the difference among the four means of education level and among five means of age. We measured such differences when we determined them to be sufficient. In this case, supporting question were: What level of education among the four education levels influenced every factor? Which age group influenced every factor? Which parameter predicted every factor most strongly? Were there any trends in our predictions of parameters?

LRA, or linear regression analysis, is used to predict the outcome of a dependent variable, based on independent (or explanatory) variables. These results indicate whether variations in the dependent variable are statistically significant [55]. We applied this measure when we had determined that the difference was sufficient. A supporting question was: Is there any factor that can predict another factor? To be more specific, we asked: Is there any factor which predicts respondent's choice of buying new products or paying more? If so, what is level of accuracy of such a prediction?

2.2. Scenario Workshop

The virtual workshop "Food, feed, and fertiliser from biowaste customer insights of social acceptance and S-LCA" was organised on 24 February 2021. The starting point was acknowledging that we did not know enough about the level of social acceptance of new sources of protein. As such, an introductory workshop was organised to gain insights. How can the food system be changed? What are the barriers, challenges and opportunities? Finally, what are the consumer expectations (e.g., price, taste, texture, or something else)?

The 28 participants in the social acceptance workshop undertook a pre-survey with two questions: What do you know already, and which information is vital for the understanding of customers. Nine responses were received.

The responses indicated that they had very little knowledge about the social acceptance of new products derived from biowaste. As such, the insights were as follows:

- We should evaluate the general acceptance by citizens and customers, their demands and preferences, and whether they are willing to consume insect-based products.
- We should have knowledge about the price and taste of the products, and whether such products will be available.
- We need to ensure the safety and bio-activity of food or feed products and to demonstrate that their properties are better or equal to those of current products obtained using conventional methods.
- We should deepen our knowledge of regulatory and legal aspects.
- We should deepen our knowledge of potential financial support from public entities and authorities.
- We should include climate arguments when marketing and selling the products.
- Enterprises likely have deep knowledge of end customer needs (B2B).
- Fertiliser producers should be addressed, in terms of their challenges and successes.
- We should endeavour to gain new ideas and insights into business concepts and models.

The workshop started with two keynotes: an introduction to social acceptability and new bio-products [31] and introduction to the S-LCA [56].

The workshop applied the Prospective Rapid Impact Assessment (PRIA) approach [32]. PRIA is a future scenario workshop method focusing on future impact. Often, the portfolio problems are evoked, where the task is to find a set of actions that meet the objectives of the various stakeholders as well as the specific targets (e.g., CO_2 emission reduction) and constraints (e.g., costs). The overall challenge is that the development and evaluation of portfolios can become very complicated, especially if the number of candidate actions is large, and if there are synergies or antagonistic effects among the actions. Portfolio Decision Analysis (PDA) is a powerful approach for dealing with complex portfolio problems. It refers to the body of theory, methods and practice which support decision makers in making informed multiple selections from a set of alternatives with the help of mathematical models that account for relevant constraints, preferences and uncertainties [57]. Here, PDA was used to develop decision scenarios concerning social acceptance. The portfolio comprised a collection of actions which could be recommended for consideration when designing and deciding actions intended to improve the organisation [33,35]. At the workshop, ideas were brainstormed and sorted into six categories, which were evaluated using the INTO multicriteria (MC) visual evaluation tool (into.savonia.fi). Participants were asked to think and add ideas from three point of views: the consumer, the policy maker, and the producer. In order to create ideas for different customers, participants were asked to imagine themselves as customers. We applied a customer persona framework developed in Norway by Bremnes [58]. The personas were stereotypes with very different values when it comes to food and life in general.

The idea categories were: (1) weaknesses, missing capacities and vulnerabilities, (2) strengths and existing capacities, (3) values, hopes and goals, (4) actions, strategies and means, (5) threats, risks and fears, and (6) opportunities and possible worlds [32,34,35,37]. The ideas were then moved to an evaluation environment, where they were evaluated on a scale from 1 to 7. The evaluation criteria were: (1) from the point of view of policy makers: does the idea increase social acceptance (1 = not at all, 7 = very much); (2) from the point of view of producers and the value chain: opinions of the producer about the social acceptance or social impact (1 = not acceptable at all 7 = very easily acceptable); and (3) social acceptance from the point of view of the consumer: (1 = not acceptable at all, 7 = very easily acceptable). Fifty-seven ideas were created, and 14 evaluators evaluated them against the three evaluation criteria, resulting in 763 individual evaluations. The workshop duration was 2.5 h.

The INTO tool features PDA analysis based on a core index and reporting according to three PRIA zones. PDA was used to select an optimum portfolio of actions for the future. The overall results are presented at the PRIA framework (Figure 3), where the ideas are listed. Figure 4 lists the best ideas according to their core-index by PRIA-zones. The PRIA zones are: (1) protection zone, where threats meet weaknesses; (2) empowerment zone, where opportunities meet strengths; and finally (3) innovation zone, where objectives meet actions [33,34].

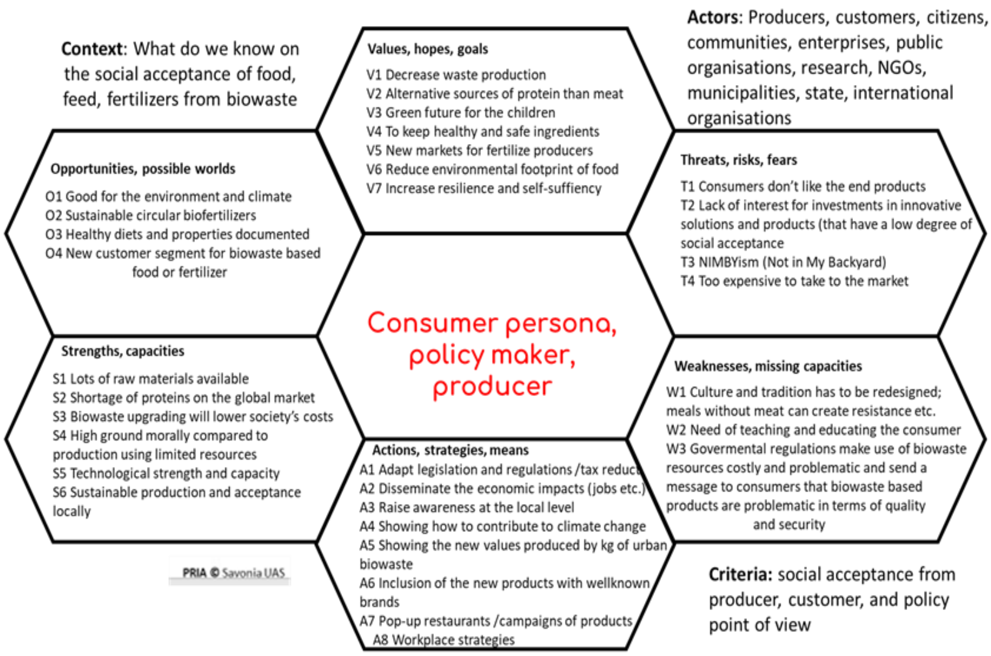

Figure 3. The social acceptance workshop results within the PRIA framework, where ideas were prioritised according to their core index. Reprinted/adapted with permission from Refs. [33,34]. Savonia University of Applied Sciences, 2019.

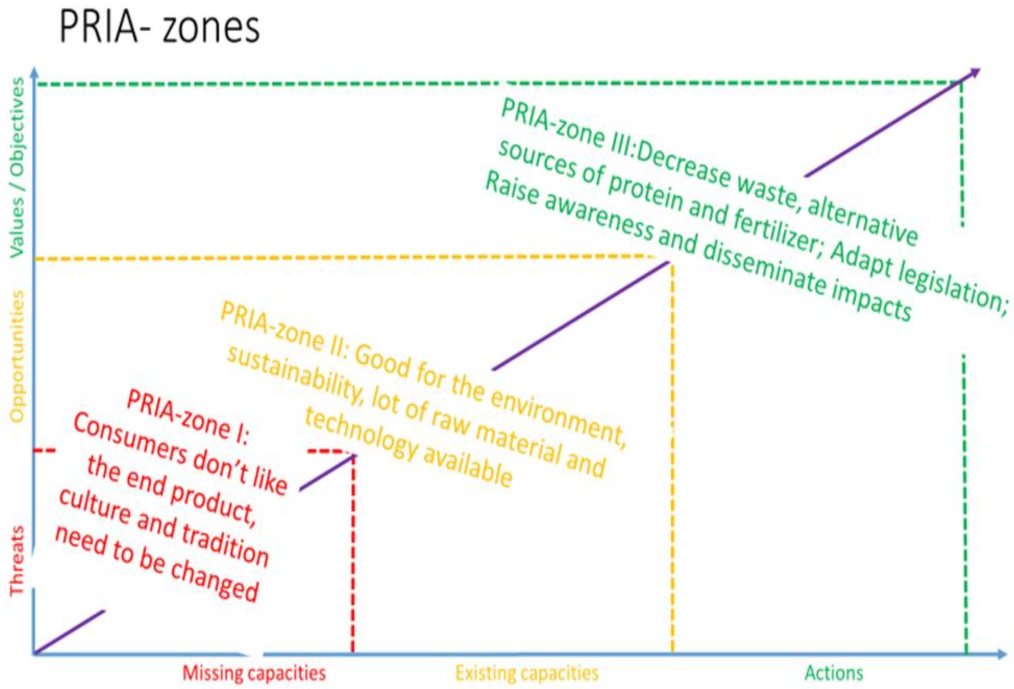

Figure 4. The social acceptance workshop results for three PRIA zones [33,34]. Reprinted/adapted with permission from Refs. [33,34]. Savonia University of Applied Sciences, 2019.

3. Results and Discussion

The interviews yielded valuable information and insights on social context: end-product definition, goals of the study and target groups, participants, acceptance levels, as well as information about the operational environment (e.g., legislative, political). The expert interviews yielded some information about market acceptance: Supermarket chains, retailers, and companies selling feed, fertilisers, and pesticides to the agricultural sector, as well as business to business. Safety and legislation are key components in achieving social acceptance. According to European waste and food legislation, waste cannot be used as material for feed of food, while "technical" use, e.g., as bio-diesel, is possible. The definitions and requirements in the waste and food directives should be followed. Biowaste from catering, if processed correctly, could be an option for a side-stream for use in the value chain, if it is not classified as waste. Novel foods, for example, those produced with insects, need authorisation from the European Commission. The safety of such novel foods is assessed, upon request by the Commission, by the European Food Safety Authority (EFSA) [59] (EU, 2015).

In order to achieve market acceptance, there are indications that people would like to buy products with bio-products if they have healthy properties. VALUEWASTE has undertaken laboratory tests on the toxicological, functional and microbiological properties of the bio-compounds produced in two value chains: three bio-compounds related to single cell proteins (SCPs) and two bio-compounds related to insect production processes; bio-fertilisers have not yet undergone laboratory testing.

The driver for change in customer behaviour may be related to attractive, novel products and circular value chains, the better use of biowaste, sustainability, and adaptation to climate change related to water scarcity and soil degradation. However, the market is not ready for these new bio-products, and we lack information about customer profiles and drivers of behavioural change, which will be needed to increase the market acceptance.

There are factors which may increase socio-political and community acceptance. For example, the creation of new jobs, business sustainability, better local resilience, less CO_2 emissions, and the development of a more sustainable society.

The social acceptance workshop (Figures 3 and 4) produced a joint view of social acceptance based on: firstly, the perspectives of policy makers; secondly, on the perspectives of producers and the value chain; and thirdly, of the opinions of consumers. As a major threat, participants noted that consumers would not like the end product, and as weaknesses, they identified the culture and traditions which would need to be changed.

In terms of opportunities, the products are good for the environment and are sustainable. Regarding existing capacity, there is a range of raw material and technology available. The biggest value comes through decreasing waste and the obtention of alternative sources of protein and fertiliser. The main action would be adapting legislation and raising of awareness and the dissemination of information about the positive impacts of such a business endeavour. The results were interpreted critically, since the participants in the workshop were represented value chains and experts; consumers, citizens and policy makers were present only indirectly, based on the expertise of the participants. The involvement of customers, businesses and policy makers is needed to develop a clear vision and new strategies in the context of the circular economy through knowledge exchange, education and regulatory measures [60]. The PRIA approach proved itself to be a powerful tool for interactions and to gain a joint understanding of the different aspects of social acceptance. The PRIA zones were used to interpret the result regarding fortification: we need to decrease waste, seek alternative sources of protein and fertilisers, adapt legislation [55], raise awareness and disseminate information about the positive environmental impact.

The participating municipalities, Murcia and Kalundborg, showed interest in citizen perceptions of sorting biowaste and in knowing whether people's mindsets could be changed regarding the products VALUEWASTE is producing. Our in-depth analyses of the results answer these questions in part. Our goal was to gain an understanding of the complex factors affecting consumer behaviour and new bio-products in a sustainable food system. Consumer behaviour can be influenced by command-and-control, market-based, or voluntary change approaches [22]. We need to change both production and behaviour. The key question is: What is the vital behaviour that we need to change? [61].

One key finding, i.e., the lack of information about consumers, needs to be addressed. The survey results indicated that this could be an important factor influencing influence customer behaviour. Consumers identify and favour products producing fewer carbon emissions.

3.1. Statistical Results of the Social Acceptance Survey

Using the "Minimum residual" extraction method, "Oblimin" rotation, and "Factor's statistics summary", we defined the five following factors.

Factor 1: α = 0,95; ω = 0,95, "Valuation of properties for insect/bacteria/fungi products". Questions: 50–59.

Factor 2: α = 0,88; ω = 0,89, "Importance of Socio-economic issues". Questions: 28–40.

Factor 3: α = 0,89; ω = 0,90, "Acceptance of protein products produced by insect/bacteria/fungi". Questions: 41–46.

Factor 4: α = 0,83; ω = 0,83, "Societal needs regarding the use of biowaste as a source of new products". Questions: 12–16, 18 and 19.

Factor 5: α = 0,83; ω = 0,83, "The choice to buy or pay more for new products". Questions: 60, 61 and 63–66.

The *t*-test showed significant differences between females and males in Factor 2 (t = 4.66, p < 0.001, d = 0.44) and Factor 3 (t = −2.27, p = 0.023, d = −0.21), and between residents of Denmark and Spain in Factor 4 (t = −4.95, p = <0.001, d = −0.42).

ANOVA analyses showed that respondents with technical/vocational education level accepted Factor 3 (t = −2.85, pHolm = 0.027, d = −0.42) and Factor 4 (t = −3.46, pHolm = 0.002, d = −0.47) less than respondents with Bachelor's or Master's level education.

The LRA model is statistically significant (F = 109.04, p < 0.001). The model R2 = 0.41. Factors 1 (β = 0.30, p < 0.001), 3 (β = 0.37, p < 0.001) and 4 (β = 0.16, p < 0.001) were significant predictors of Factor 5. The collinearities of Factor 1 (VIF = 1.16), Factor 3 (VIF = 1.42) and Factor 4 (VIF = 1.28) were low.

3.2. Discussion of the Statistical Results

EFA was performed by Jamovi instruments, including choosing an extraction method, based on the correlation and rotation of data to clarify interpretation, and decision making concerning the most appropriate number of factors. By applying the Minimum residual extraction method and Oblimin rotation, we chose "Number of Factors" based on parallel analyses. Initially we opted for 10 factors. The Factor statistics summary showed 48.13% of cumulative representation, which is acceptable. The Bartlett's test showed $p < 0.001$ and KMO showed 0.90 overall, which is high. Both tests assured that these data were appropriate for factor analyses.

The number of factors that were initially extracted by parallel analyses did not reveal the best solution; it was difficult to interpret the results of those factors. We created a Scree plot to determine the number of factors, based on eigenvalues greater than one, which is like the SPSS approach. Thus, we reduced the number of factors to seven. Meanwhile, the inter-factor correlation statistics showed weak correlations among elements of Factors 6 and 7. Thus, we rearranged factors again by eliminating the weak variables from each factor. The variables that showed a "Uniqueness" value lower than sixty, meaning that they described less than 40% of cases, were eliminated.

Finally, re-grouping variables based on eigenvalues greater than one and "Oblimin" rotation yielded five factors. Initial eigenvalue and Scree plot also confirmed this decision. Statistical summaries of the factors improved, showing 50.17%. Inter-factor correlations were consistently strong. Bartlett's $p < 0.001$ and overall KMO was 0.91.

Our next steps were to check the reliability coefficients of each factor, to apply RA, and to determine the means of each factor, giving names to new mean-variables. The coefficients provided a basis to confirm that the variables describing each group had obtained excellent internal consistency. Consequently, we created mean scores and assigned names to each factor.

The *t*-test, examining mean differences, was performed twice. First, we checked gender differences and then residence differences. Initially, we checked for normal distribution and had to explain the normality. Figure 5 shows a normality distribution graph for Factor 1. At first glance, this graph looked non-normally distributed; however, we considered this distribution normal, because the five-level Likert scale answers were complemented with a sixth one, zero, which indicated a "nonapplicable answer". As such, the mean of the graph moved to the right. Moreover, almost all of the answers were grouped around three and five, where we observed a bell-shaped normal curve.

In addition, we extracted a descriptive statistic, where Skewness and Kurtosis distribution for all five factors were clearly shown (see Table 3). We were not strict at this point, so we applied a rule of thumb and observed a skewness of not more than around (+/−) 2 and kurtosis of not more than around (+/−) 6 [62], which confirmed the normality of distribution.

The *t*-test results showed Factor 2 as statistically significant regarding gender differences. This explained the statistically significant difference between females and males in terms of the importance placed on socio-economic issues ($t = 4.66$, $p < 0.001$, d = 0.44). The effect size was small, i.e., about 4%. We also considered Factor 3 as statistically significant concerning gender differences, i.e., there was a statistically significant difference between males and females in accepting protein products produced by insect/bacteria/fungi ($t = -2.27$, $p = 0.023$, d = −0.21). The effect size was small, i.e., about 1%. The results, clarified from Table 2, are presented in Table 4.

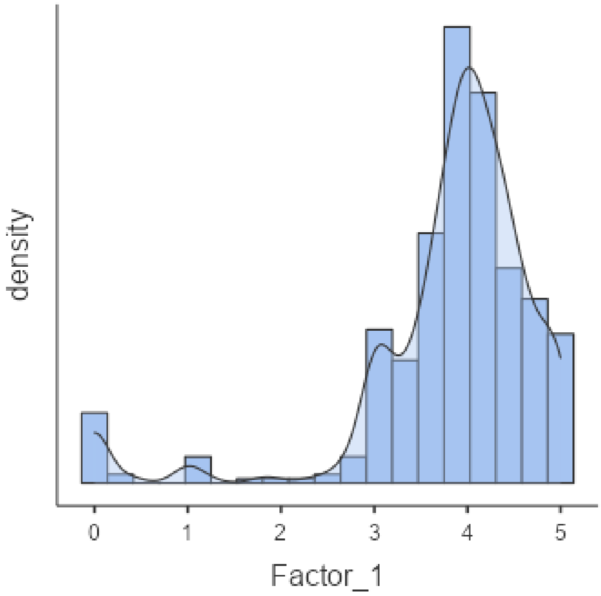

Figure 5. Normal distribution graph of Factor_1: "A valuation of the properties of insect/bacteria/fungi products".

Table 3. Descriptive statistics (skewness not exceeding (+/−) 2 and kurtosis not exceeding (+/−) 6—marked red).

	Factor_1	Factor_2	Factor_3	Factor_4	Factor_5
N	473	473	473	473	473
Missing	0	0	0	0	0
Skewness	−2.27	−1.08	−0.98	−1.46	−1.15
Std. error skewness	0.11	0.11	0.11	0.11	0.11
Kurtosis	6.16	1.18	1.65	3.45	2.22
Std. error kurtosis	0.22	0.22	0.22	0.22	0.22

Table 4. Independent sample *t*-test results—Gender Differences (statistically significant factors and Cohen's d values, where *p* is less or about 0.001—marked red).

		Statistic	df	*p*		Effect Size
Factor_1	Student's *t*	0.16	471	0.872	Cohen's d	0.02
Factor_2	Student's *t*	4.66	471	<0.001	Cohen's d	0.44
Factor_3	Student's *t*	−2.27	471	0.023	Cohen's d	−0.21
Factor_4	Student's *t*	0.12	471	0.905	Cohen's d	0.01
Factor_5	Student's *t*	1.33	471	0.184	Cohen's d	0.13

The Levene's test was significant ($p < 0.05$), suggesting a violation of the assumption of equal variances.

We performed the same *t*-test for country of residence. As observed in Table 5, residents of Denmark differed from those of Spain only in terms of accepting societal need to use biowaste as a source of new products ($t = -4.95$, $p = <0.001$, d = −0.42).

However, it is interesting to note an advantage of using a descriptive plot from the additional statistics of the independent samples *t*-test. These plots depicted a difference between two variables and helped us interpret the results. Figure 6 shows the two means for Denmark and Spain, respectively. We see that these means were not equal, i.e., that of Spain was higher than that of Denmark; they differed by around 4%, which was considered small.

Table 5. Independent sample *t*-test results—Residential differences (statistically significant factor and Cohen's d value, where *p* is less or about 0.001—marked red).

		Statistic	df	*p*		Effect Size
Factor_1	Student's *t*	0.57	471	0.568	Cohen's d	0.05
Factor_2	Student's *t*	−0.39	471	0.699	Cohen's d	−0.04
Factor_3	Student's *t*	0.98	471	0.326	Cohen's d	0.09
Factor_4	Student's *t*	−4.59	471	<0.001	Cohen's d	−0.42
Factor_5	Student's *t*	1.2	471	0.23	Cohen's d	0.11

The Levene's test was significant ($p < 0.05$), suggesting a violation of the assumption of equal variances.

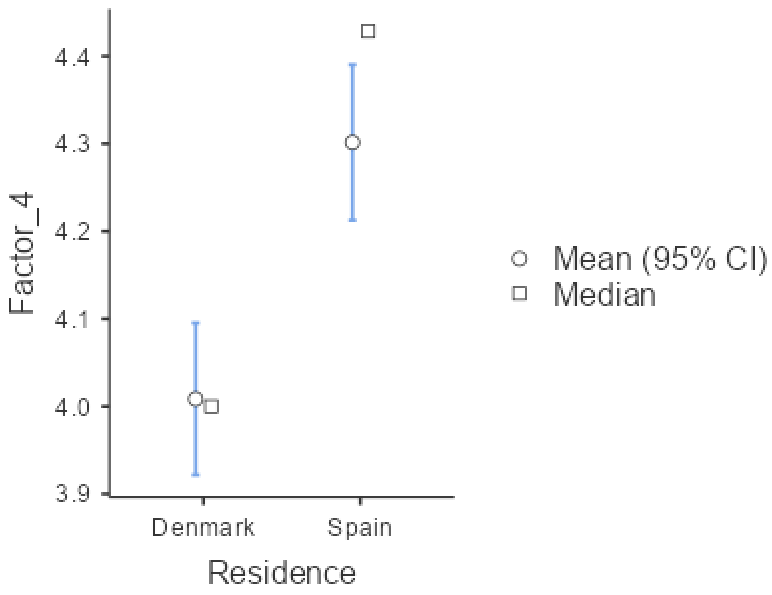

Figure 6. Descriptive plot for Residence of Factor_4: "Societal needs regarding the use of biowaste as a source of new products".

ANOVA can determine analogous differences, but only among the variables which have more than two meanings. In our case, these variables were level of education and age. The explanation of predictions comes from a difference and an influence. In fact, when a parameter shows a difference, it also shows an influence on the factor. For example, if a female gives the most positive score to a factor, and ten males give the most negative score to the same factor, we can infer both that males differ from females and males influence or even predict this factor.

One-Way ANOVA showed significance in Group 3, $p = 0.048$, and Group 4, $p = 0.009$. Next, we referred to the post hoc test and Games-Howell (unequal variances) of One-Way ANOVA. From our analysis, we found a statistical significance between Technical and Bachelor's education levels in Factor 3. Statistical significance was also shown between Technical and Master's education levels in Factor 4. A visual description of statistical significance can be found in Figure 7, explaining the difference, influence and trends of Factors 3 and 4. A graph of Factor 3 showed the difference among Technical and Bachelor's level education. We observed that Bachelor's level did not differ from Master's or Elementary education. However, Technical education did. Similar inferences appeared for Factor 4. Technical education differed from Bachelor's and Master's level educations, whereas Bachelor's, Master's and Elementary levels did not differ from each other. Moreover, we observed a trend in Factor 4, which can be interpreted as follows: the higher the education level of the respondent, the higher the propensity to accept societal needs to using biowaste as a source for new products. We did not consider elementary education as meaningful, because that education level was represented by an incredibly small number of participants. Thus, most probably, respondents from this group picked the answer based on its popularity instead of making an informed decision.

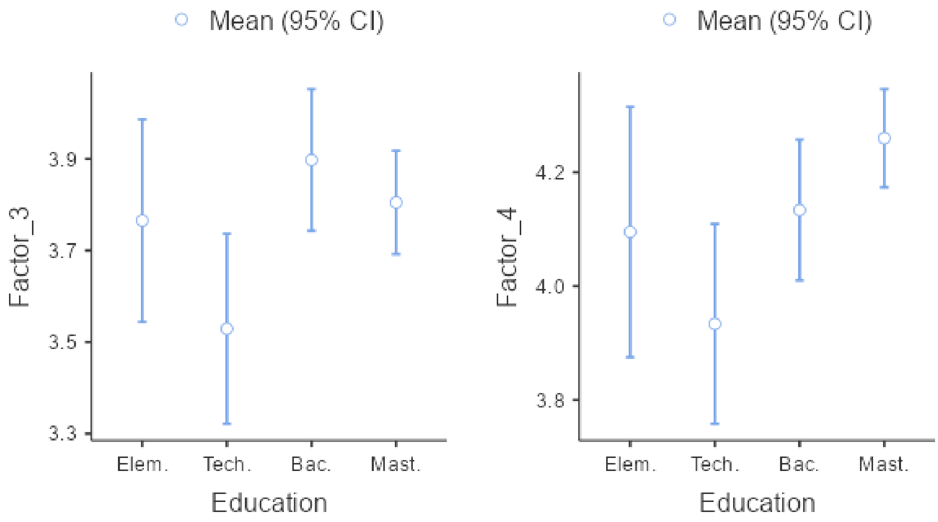

Figure 7. One-way ANOVA plots of Factor_3 and Factor_4.

Further, we had to define the effect size of the difference among these four elements. We used post hoc tests from our ANOVA analyses, where we measured Cohen's d. Based on the statistics shown in Table 6a, we inferred the following: respondents with comparatively lower education levels, i.e., technical or vocational, were less accepting of protein products produced by insect/bacteria/fungi than other respondents. However, the difference was small, representing about 4% ($t = -2.85$, pHolm = 0.027, d = −0.42). Based on the statistics shown in Table 6b, we inferred the following: respondents with comparatively lower education levels, i.e., technical or vocational, were less accepting of societal needs to use biowaste as a source for new products. The difference was moderate, representing about 5% ($t = -3.46$, pHolm = 0.002, d = −0.47).

Table 6. (**a**) Post hoc comparison ANOVA—Factor 3 "Acceptance of protein products, produced by insect/bacteria/fungi" (statistically significant pair of Education level and Cohen's d value, where Pholm was less or about 0.001—marked red). (**b**) Post hoc comparison ANOVA—Factor 4 "Societal needs regarding the use of ciowaste as a source for new products" (statistically significant pair of Education levels and Cohen's d value, where Pholm is less or about 0.001—marked red).

(a)

Education	Education	df	*t*	Pholm	Cohen's d
Elem.	Tech.	469	1.2	0.916	0.27
	Bac.	469	−0.7	1	−0.15
	Mast.	469	−0.22	1	−0.05
Tech.	Bac.	469	−2.85	0.027	−0.42
	Mast.	469	−2.44	0.074	−0.31
Bac.	Mast.	469	0.92	1	0.11

(b)

Education	Education	df	*t*	Pholm	Cohen's d
Elem.	Tech.	469	1.04	0.734	0.23
	Bac.	469	−0.26	0.797	−0.06
	Mast.	469	−1.16	0.734	−0.24
Tech.	Bac.	469	−1.95	0.258	−0.29
	Mast.	469	−3.64	0.002	−0.47
Bac.	Mast.	469	−1.59	0.452	−0.18

Comparisons are based on estimated marginal means.

ANOVA showed no age difference in any factor, meaning that all groups responded similarly. We inferred this fact based on the *p* level, that was much higher than 0.001, as shown in Table 7.

Table 7. One-Way ANOVA—Age level differences (No statistically significant factors, where *p* was higher than 0.001—marked red).

One-Way ANOVA					
		F	**df1**	**df2**	***p***
Factor_1	Welch's	0.87	4	20.60	0.496
	Fisher's	0.67	4	468	0.610
Factor_2	Welch's	1.39	4	20.52	0.271
	Fisher's	1.56	4	468	0.184
Factor_3	Welch's	0.83	4	20.79	0.524
	Fisher's	0.67	4	468	0.612
Factor_4	Welch's	0.49	4	20.58	0.744
	Fisher's	0.56	4	468	0.693
Factor_4	Welch's	1.08	4	20.47	0.390
	Fisher's	1.49	4	468	0.204

LRA was the final analysis; this helped us to predict one factor based on other factors. We were interested to check whether our model, including four predicting factors (from 1 to 4) as independent factors, and factor 5 as a dependent factor, explained variations in Factor 5, i.e., "The choice to buy or to pay more for the new products".

Based on the data in Table 8, we could infer that the model was statistically significant ($F = 109.04$, $p < 0.001$). The model explained 41% of the variance of Factor 5. Three factors, i.e., 1 ($\beta = 0.30$, $p < 0.001$), 3 ($\beta = 0.37$, $p < 0.001$) and 4 ($\beta = 0.16$, $p < 0.001$), were significant predictors of Factor 5. The effect of Factor 3 was the strongest, at 37%. The effect of Factor 1 was 30%, while that of Factor 4 was 16%. Factor 2 had no significant statistical effect. The overall effect of these three factors was 41%. Despite the correlation among predictors, collinearity did not make sense for any of the three factors: Factor 1 (VIF = 1.16), Factor 3 (VIF = 1.42), and Factor 4 (VIF = 1.28). ANOVA showed no age difference in any factor, meaning that all groups responded similarly. We inferred this fact based on the *p* level, that was much higher than 0.001, as shown in Table 7.

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Table 8. Linear regression analysis. Model fit measures (statistically significant predictors and standard estimate values, where p was less or about 0.001—marked red).

Model Fit Measures						
			Overall Model Test			
Model	**R**	**R^2**	**F**	**df1**	**df2**	**p**
1	0.64	0.41	109.04	3	469	<0.001

Model Coefficients—Factor_5 (choice to pay more)

Predictor	Estimate	SE	t	p	Stand. Estimate
Intercept	0.35	0.2	1.71	0.088	
Factor_1	0.26	0.03	7.88	<0.001	0.3
Factor_3	0.36	0.04	8.76	<0.001	0.37
Factor_4	0.2	0.05	4.05	<0.001	0.16

4. Conclusions

Social acceptance is an important factor to consider when developing new products or circular economy business models based on the reuse of biowaste. In our research, it was found that citizens are well informed and deeply interested in such new products and their properties. However, the general public has no experience with using them, because such products are not yet widely available.

The dataset (N = 523) obtained was smaller than expected (N = 2000), but it provided a good basis to study differences and trends. Regardless of small effect size, the results should be interpreted critically.

When comparing the two study regions, Murcia and Kalundborg, it was found that the level of social acceptance of new products from biowaste, at large, showed no difference in terms of age, gender, education, or country of residence. However, more educated customers tended to be more flexible in terms of accepting new products than those with lower levels of education. The data indicated that women reflect more deeply upon socio-economic issues than men, although men showed higher acceptance of protein products made with insects or SCP.

Indicators fortifying market acceptance signal that people would prefer to buy bio-based-products with healthy properties and that they accept the societal need to use biowaste as a source for new products.

The safety of the products is important for all customers. Various drivers for change of customer behaviour are the presentation of attractive, novel products and circular value chains, the better use of biowaste, sustainability, and adaptation to climate change related to water scarcity and soil degradation. These factors fortify the development of new business models and their value proposition, increasing market acceptance of products obtained from biowaste. Market acceptance may be further strengthened by getting wider information about customer profiles, customer types and values and drivers affecting behavioural change.

Socio-political and community acceptance could be fortified through the creation of new jobs and sustainable business models, better local resilience, less CO_2 emissions, and reduced carbon footprint. Regulatory aspects also need to be considered. Therefore, this study provides useful insights to be considered when designing circular economy business models for new bio-products, especially for value propositions for different customer segments.

We conclude that our study, which engaged citizens, consumers, producers and policy makers, provides insights into what is important for the social acceptance of new products (protein sources for food and feed, and recycled fertilisers) derived from biowaste in the two study regions, Murcia and Kalundborg. Our observations, based on analyses of the results from three dimensions of social acceptance, provide guidance on how to fortify social acceptance as part of new circular economy business models. This study provides a broader framework for social acceptance in comparison to studies where the notion is mainly measured as willingness to pay [63,64]. The fortification of social acceptance, together with actions which improve the behavioural, social and cultural dimensions, will enrich value propositions and customer attitude towards circular economy business models, addressing social acceptance dimensions for the development of a sustainable bioeconomy in Europe.

Author Contributions: T.E.: Conceptualisation, methodology, investigation, writing, project administration, funding acquisition, supervision, formal analysis, review and editing. O.S.: Conceptualisation, methodology, investigation, formal analysis, writing, visualisation, review and editing. M.K.: Conceptualisation, methodology, review and editing, writing, supervision. D.F.G.: Methodology, investigation, review and editing, writing. M.M.: Methodology, investigation, formal analysis, visualisation, review J.M.S.D.: Supervision, review and editing. M.V.S.: Investigation, review, supervision. J.I.H.: Investigation, review, supervision. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the VALUEWASTE Ethics Committee.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. The survey results were handled according to the European legislation on data management (GDPR), and ethical regulations. Answers were given anonymously and no results can be connected to individual persons.

Data Availability Statement: Data supporting reported results generated can be found at: valuewaste.eu (accessed on 6 October 2022).

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Abbreviations

The following abbreviations are used in this manuscript:

alpha	Cronbach's α coefficient
ANOVA	Analysis of variance test
Bartlett's	Bartlett's test of sphericity
CE	Circular Economy
CBE	Circular Bioeconomy
Cohen's d	Standardized mean difference, measuring effect size
EFA	Exploratory factor analysis
EFSA	European Food Safety Authority
INTO	Online Innovation Tool at into.savonia.fi
KMO	Kaiser-Meyer-Olkin test
LRA	Linear regressions analyses
MC	Multicriteria
omega	McDonald's ω coefficient
PDA	Portfolio Decision Analysis
PRIA	Prospective Rapid Impact Assessment
RA	Reliability analyses

SPC	Single cell protein
S-LCA	Social life cycle assessment
t-test	Student's *t*-test
VABBs	Values, Attitudes, Beliefs and Behaviours

Appendix A

I. The use of supporting questions for the statistical analyses as stimulating triggers in fortifying social acceptance.

We used the following supporting questions to enforce a research question and designate its fringes. Supporting questions helped us to be more specific in explaining results of each analysis.

A supporting question for an EFA interpretation can be: are there group of factors that explain shared variance in the data? We can conclude and answer this supporting question: five groups of variables characterize most correlated variables that create five groups of factors and identify the structure of the relationship between the variables and the respondents, include following questions of the survey:

Factor 1. A group of variables: 50,51,52,53,54,55,56,57,58,59.

Factor 2. A group of variables: 28,29,30,31,32,33,34,35,36,37,38,39,40.

Factor 3. A group of variables: 41,42,43,44,45,46.

Factor 4. A group of variables: 12,13,14,15,16,18,19.

Factor 5. A group of variables: 60,61,63,64,65,66.

A supporting question for RA interpretation can be: are these factors obtain consistency? Is there a good bases to assign name to those factors as a factor describing the latent factor? If yes, at which level? We can conclude that we have grounds to confirm that variables describing each group obtain internal consistency at excellent level. We can assign names to these five mean-score variables, as follows:

Group 1: α = 0,95; ω = 0,95, named "A valuation of properties for insect/bacteria/fungi products".

Group 2: α = 0,88; ω = 0,89, named "Importance of Socio-economic issues"

Group 3: α = 0,89; ω = 0,90, named "Acceptance of protein products, produced by insect/bacteria/fungi"

Group 4: α = 0,83; ω = 0,83, named "Society needs for using Biowaste as a source for new products"

Group 5: α = 0,83; ω = 0,83, named "A choice to buy or pay more for new products".

Supporting questions for *t*-test analysis can be: is there a difference in gender or country of residence in any determined factor? If any, what is the level of that difference? We can define the difference between genders in Factor 2 and Factor 3 statistically significant. The levels are small and about 4% and 1% respectively. We can define the difference between residents of Denmark and Spain statistically significant in Factor 4. Spain residents influence is higher than residents of Denmark. The level of difference is small and about 4%.

A supporting question for ANOVA can be: which level of education among four education levels influences every factor? Which age group among age groups influences every factor? Which parameter influences/predicts every factor more strongly? Are there any trends in parameter influences/predictions? Factor 3 and Factor 4 are influenced by respondents with bachelor or master education levels more strongly than those with technical or vocational education levels. We can detect following trends: the higher level is the education of respondents the higher the influence on Factor 3 and Factor 4. Factors 1, 2 and 5 showed no significant influence from education levels. None Factors shoed any influence/prediction from any age group.

A supporting question for LRA can be: is/are there any factor/s, among previously determined, that can predict another factor? To be more specific we asked: is there any factor, which predicts respondent's choice of buying new products or paying more? If yes, what is level of that prediction?

Overall effect of three factors is 41%. Only three Factors 1, 3 and 4 are significant predictors of factor 5. The effect of Factor 3 is the strongest and equals 37%. The effect of Factor 1 equals 30%. The effect of factor 4 equals 16%. The effect of factor 2 has no significant statistical effect.

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