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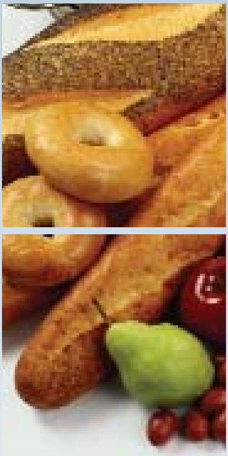
Synthesis report No 2:

The Different Uses of Food Composition Databases

By Claire Williamson
British Nutrition Foundation



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Contents

1. Introduction

Food composition databases (FCDBs) provide detailed information on the nutritional composition of foods, usually from a particular country. Food composition data may be available in different formats e.g. paper-based, often referred to as food composition tables, or electronic versions, known as nutrient databases or databanks. FCDBs provide values for energy and nutrients (e.g. protein, vitamins and minerals) and other important food components (e.g. fibre) for each of the foods listed. These values are based on chemical analyses which are carried out in analytical laboratories or are estimated from other appropriate data. The figure below shows an extract from the UK food composition tables, as an example.

Composition of food per 100g edible portion

No	Food	Protein g	Fat g	Carbohydrate g	Energy kcal	Energy kJ
952	**Grapefruit**, *raw*	0.8	0.1	6.8	30	126
953	canned in juice	0.6	Tr*	7.3	30	120
954	canned in syrup	0.5	Tr*	15.5	60	257
955	**Grapes**, average	0.4	0.1	15.4	60	257
956	**Guava**, *raw*	0.8	0.5	5.0	26	112

* Trace amount of nutrient

Source: FSA (2002) *McCance and Widdowson's The Composition of Foods, 6th Summary Edn*. Cambridge: Royal Society of Chemistry.

Data on the composition of foods are essential for a variety of purposes in many different fields of work, for example the assessment of energy and nutrient intake in individuals or groups. They are also necessary to assess the effect of diet on health and disease outcomes and therefore are an essential pre-requisite to epidemiological research. Ultimately, they help in the development of dietary guidelines for population groups and in planning menus for schools, hospitals, prisons and the armed forces. They have even been used to plan the food ration requirements for polar expeditions. The wide range of applications in a variety of other sectors include clinical dietetic practice, sports nutrition, the food industry (e.g. product development and food labelling), government food and health departments (e.g. target setting) and in nutrition education and health promotion.

This report aims to:

- outline the different ways in which FCDBs are used
- consider the current limitations of FCDBs
- discuss potential future developments and the role of *EuroFIR*.

2. The different uses of food composition databases

The table opposite outlines the different uses of food composition databases and tables, within each of the main sectors of use (see table 1). There are some general uses of food composition data, which apply to most users, including estimating the nutrient content of foods, comparing different foods for their nutrient composition and identifying which foods are good sources of particular nutrients. Some uses are unique to a particular sector, such as devising special diets for patients within clinical practice. Each of the main uses of FCDBs will be covered in more detail, throughout this section.

Table 1: *Summary table showing the different uses of food composition data, by field of work.*

	Clinical practice	Research	Public health/ education	Food industry
Estimating/comparing the nutrient content of foods	✓	✓	✓	✓
Identifying sources of particular nutrients	✓	✓	✓	
Analysing individuals' diets	✓	✓		
Devising special diets for patients (e.g. heart disease, coeliac disease)	✓			
Patient information	✓			
Analysing dietary survey data		✓	✓	
Assessing how dietary intake affects health and disease outcomes		✓	✓	
Devising special diets for epidemiological research		✓		
Monitoring food and nutrient availability			✓	
Development of dietary guidelines	✓		✓	
Implementation and monitoring of food legislation			✓	✓
Consumer information and education		✓	✓	✓
Preparing educational materials (e.g. for schools)			✓	
Food labelling and nutrient claims				✓
Product development and reformulation				✓
Marketing of products				✓
Recipe and menu development and analysis		✓	✓	✓
Devising special diets for healthy people with particular needs (e.g. athletes)		✓		
Completing missing values in a dataset	✓	✓	✓	✓

2.1 Clinical practice

Analysing the diets of patients

Dietary assessment is carried out in clinical practice, usually by a dietitian, in order to assess a patient's nutritional status or nutritional risk. This assessment is then used as a basis for providing dietary advice or nutritional support. The method used for dietary assessment depends on the characteristics of the patient (e.g. their age, ethnic background, cognitive ability), the clinical circumstances and the purpose of assessment, which could be any of the following:

- to assess overall dietary balance
- to obtain a quantitative estimate of energy and/or specific nutrient intakes
- to identify nutritional deficiencies or excesses
- to assess the risk of malnutrition
- to monitor compliance with dietary advice.

A typical method of dietary assessment used in the clinical setting is obtaining a dietary history, such as a 24-hour recall, where the patient is asked to recall all the foods and drinks they consumed over a 24-hour period. This method has the advantage of being quick and simple to perform, which is an important consideration in clinical practice, and is also not burdensome on the patient. Although a single 24-hour recall is not usually sufficient to provide a quantitative estimate of nutrient intake, it can be used to reveal major dietary inadequacies or excesses and can be a starting point to determine whether further investigation is needed (Thomas, 2001).

Other dietary assessment methods include asking the patient to complete a diet diary, which they take away and fill in over a period of 3 or more days.

This can be useful for investigating food intolerances or to monitor the effectiveness of a dietary treatment or compliance with dietary advice. However, to obtain an accurate, quantitative measure of nutrient intake, a weighed food record is required, usually collected over a period of 5 to 7 days. However, this method has its drawbacks, in particular it is more burdensome on the patient, but is more precise than other methods as gram weights are obtained for each of the foods consumed (for a more detailed discussion of different dietary assessment methods, see Nelson 2000). The dietary data can then be entered into a dietary analysis programme (utilising detailed food composition data) to determine the patient's energy and nutrient intake and assess whether the diet is meeting the patient's nutritional requirements.

Devising special diets for patients

The assessment of patients' energy and nutrient intakes is important in the determination of appropriate dietary advice or prescription of a therapeutic diet. There are a number of clinical conditions that require therapeutic diets. Therapeutic diets need to be nutritionally balanced, while controlling or restricting the intake of specific nutrients and/or food components, therefore their prescription requires a thorough understanding of the composition of foods.

Some typical examples of clinical conditions that require therapeutic diets are listed in table 2, together with the dietary components that may need to be controlled. Unfortunately, most food composition tables and databases do not list all of the components shown in the table (e.g. gluten and monoamines are usually not listed). In these cases, additional primary data sources may need to be consulted for this information (Greenfield & Southgate 2003).

Table 2: *Clinical conditions that require food composition data for the planning of therapeutic diets*

Clinical condition	Food composition information required may include:
Requiring general dietary control	
Diabetes mellitus	Energy, available carbohydrate, fat, protein, fibre
Obesity	Energy, fat
Hypertension	Energy, sodium, potassium, protein
Renal (kidney) disease	Protein, sodium, potassium
Deficiency states	
Anaemia	Iron, folate, vitamin B_{12}
Vitamin deficiencies	Specific vitamins
Metabolic disorders	
Haemochromatosis	Iron
Hyperlipidaemias	Fat, fatty acids, cholesterol
Inborn errors of amino acid metabolism e.g. phenylketonuria	Specific amino acids
Gout, xanthinuria	Purines
Gall bladder disease	Fat, calcium, cholesterol, fibre
Wilson's disease	Copper
Intolerances	
Monosaccharides, disaccharides	Individual sugars (e.g. sucrose, lactose, fructose)
Gluten (and other specific proteins)	Gluten, specific proteins
Migraine	Monoamines
Allergies e.g. nut allergy	Specific protein sources

Source: adapted from Greenfield & Southgate (2003).

The use of food composition data in the development of therapeutic diets has been facilitated by advances in information technology, particularly the development of nutritional analysis and meal planning software (Church 2006).

Patient information

The provision of dietary advice and information for patients is a core aspect of clinical dietetic practice and would not be possible without data on the composition of foods. It is important that dietary advice is given in terms of foods, rather than in nutritional terms, as people consume foods rather than nutrients and therefore find food-based dietary guidelines are easier to understand and follow. It is also easier to ensure that the diet is balanced overall, if advice is given in terms of foods that should be consumed (Thomas, 2001).

In the UK, for example, a model known as the *Balance of Good Health* is used as a basis for healthy eating advice for the general population. The *Balance of Good Health* model is a pictorial food selection guide in the shape of a plate which is designed to illustrate the principles of healthy eating (see figure 2). The model aims to deliver macro- and micronutrients to the general population in accordance with the UK dietary reference values, as well as taking into account current population dietary targets for good health (see Theobald 2004).

Figure 2: *The UK Balance of Good Health model*

The *Balance of Good Health* model can be modified to provide advice to different client groups or sectors of the population, such as the elderly or people from particular ethnic groups. This can be achieved by giving more or less emphasis to the different food groups, to achieve an increase or decrease in energy or nutrients. For example, in the case of anaemia, dietary advice would emphasise sufficient choices from the 'meat and alternatives' group and highlight other good sources of iron, together with plenty of foods from the 'fruit and vegetables' group to supply vitamin C (which enhances the absorption of iron). The model is also being used increasingly as a basis for dietary management of more complex diseases such as diabetes or coeliac disease (Thomas, 2001).

Other countries have developed their own pictorial food guides, including Germany, Sweden, Portugal, the United States (US), Canada, Mexico, China, Korea, the Philippines and Australia (see Painter *et al.* 2002). These are discussed further in the section on public health and education (section 2.3).

Food composition data are also used by dietitians to construct diet sheets with information to help patients manage particular conditions, such as heart disease, diabetes, obesity, hypertension or food allergies. In all cases, a knowledge of, as well as access to, good quality food composition data is essential for the delivery of appropriate nutritional advice.

2.2 Epidemiological research

McCance & Widdowson in 1940 are quoted as saying "a knowledge of the chemical composition of foods is the first essential in the dietary treatment of disease or in any quantitative study of human nutrition" (McCance & Widdowson 1940). This indicates the original motivation behind food composition studies, which were carried out to identify and determine the chemical nature of the food components that affect health and the mechanisms whereby chemical constituents exert their influence.

Such studies remain central to nutrition research into the role of food components in health and disease, but at an ever-increasing level of sophistication and complexity (Church 2005). The validity of nutritional epidemiological studies depends on accurate food composition and food intake data. Therefore a comprehensive FCDB that is representative of available foods is an essential pre-requisite for quantitative nutritional research (Greenfield & Southgate 2003).

Nutritional epidemiology provides a means for identifying relationships between dietary factors and health in human populations consuming usual amounts of foods and nutrients. The main purpose is to identify potential causes of diet-related diseases (e.g. cardiovascular disease, cancer, diabetes) so that these can be modified in order to reduce the burden of disease. Most studies in nutritional epidemiology are observational, where researchers assess differences in the exposure and outcome of interest to see whether a relationship exists. Although such studies cannot provide evidence of causality, they can be used to identify dietary factors that may be involved in the onset of disease.

For example, case-control studies compare past dietary exposure to a particular dietary factor between groups of individuals with and without the disease outcome. However, the problem with these types of studies is that they are susceptible to recall and selection biases, in that recalling past diet is not very reliable and also people with the disease may recall their diet differently from healthy individuals. Cohort (or prospective) studies do not have this problem and therefore their findings are considered to be more reliable, although, these studies take a long time and are expensive to carry out.

Dietary data collection is a challenging part of nutritional epidemiology – accuracy in measurement of food and nutrient intake is important in order to detect true associations. Most cohort or prospective studies use food frequency questionnaires (FFQs) to assess food intake as it would not be practical to use a more detailed method (e.g. 7-day weighed food diary) on a large cohort of participants. FFQs attempt to assess usual or typical food intake over a longer time period than is usually possible using other dietary assessment methods. Foods are listed in a questionnaire format or multiple-response grid and respondents are asked to estimate how often they consume each food and how much they usually consume (using household units) (see table 3). The FFQ is a useful method for assessing the nutrient intake of a population or group or for classifying individuals e.g. into tertiles of intake. However, it is less accurate for estimating the nutrient intakes of individuals (see Bingham *et al.* 1994).

Table 3: *Example of a section of a food frequency questionnaire (FFQ)*

In the last month... how often have you eaten any of the following types of bread or rolls?

	Never or < once per month	**1-3 days per month**	**1-2 days per week**	**3-4 days per week**	**5-6 days per week**	**Amount PER DAY on days eaten**
White bread and rolls						
Brown/wholemeal/ granary bread and rolls						
Other breads e.g. naan, paratha, chapatti, pitta						
Scones, currant bread, currant buns, teacakes						

The data on amount and frequency of foods consumed are then entered into a specially designed data entry programme which converts the food descriptions and portion size estimates into weights. This information is linked to codes for foods in tables of food composition. The final data produced by this process is the average intake of food, energy and nutrients, by day and individual. Epidemiologists are then able to examine patterns of food and nutrient intake and how these relate to health and disease outcomes.

Epidemiologists and those assessing nutritional status at a population level have particularly benefited from the development of computerised FCDBs. These can not only hold a much greater volume of data compared with printed tables, but hugely facilitate the manipulation of data, both in terms of adding new values and for the calculation and analysis of nutrient intakes (Church 2005).

Example – the EPIC study

The European Prospective Investigation into Cancer and Nutrition (EPIC) study is an example of a large prospective cohort study that has been set up to investigate the relationship between dietary factors and the incidence of different types of cancer (see www.iarc.fr/epic). EPIC is a pan-European study with around 520 000 participants taking part from 10 different European countries. This is of sufficient size to investigate even the rarest cancers and provides enough statistical power to investigate any interactions, for example with genetic polymorphisms (see Bingham 2005).

Previous cohort studies looking at diet and cancer have not been able to determine strong associations between dietary factors and different types of cancer. This is partly due to the complexity of modern food supplies but also due to the fact that many different food items have been associated with different cancers. All of these different food items have different errors associated with their measurement which can cause dietary associations to be weakened. The EPIC study attempts to overcome the effects of measurement error in a number of ways. It is the largest prospective study ever undertaken to investigate the relationship between diet and cancer and the large sample size means that statistical power is increased, enhancing the chance of identifying associations. Furthermore, because it involves participants from 10 European countries, there is a wide variation in dietary habits within the cohort which also increases the likelihood of detecting associations. Measurement error is further minimised by correcting results using more detailed dietary estimates (standardised 24-hour recall) from a representative sub-sample of the cohort (Bingham & Riboli 2004).

Most countries in Europe have their own national FCDBs which have been compiled using country-specific procedures and aim to provide comparable nutrient composition data at the national level (Charrondiere *et al.* 2002). However, in order to establish relationships between food and nutrient intakes and disease in the EPIC study, a standardised European FCDB was needed. Since such a database does not currently exist, the EPIC study had to develop a method for improving the comparability of the food composition data from the different participating countries. This involved building new matrices using detailed food lists derived from the standardised (computerised) 24-hour recall data collected from a representative sample from each of the EPIC cohorts (approx 35 000 respondents). This helped to overcome the problem of trying to reduce differences between food lists in the different databases. Furthermore, all recipe data was systematically broken down into constituent ingredients in order to optimise comparison between countries. The compilation of nutrients was carried out using standardised sources of nutrient data or algorithms. For foods common to several countries, the same nutrient values could be used, but for country-specific foods, nutrient values specific to that country were used (Slimani *et al.* 2000).

The EPIC study has so far shown that saturates intake is linked to breast cancer in women (Bingham *et al.* 2003). It has also found that dietary fibre and fish appear to be protective against colorectal cancer, while high intakes of red and processed meat appear to increase the risk of large bowel cancer (Norat *et al.* 2005). International epidemiological studies, such as the EPIC study, have highlighted the need for the standardisation of food composition data produced at the national level (Deharveng *et al.* 1999). The methodology utilised in the EPIC study to improve comparability between European FCDBs is now being used as a basis to develop protocols for establishing a pan-European database within the *EuroFIR* project.

Furthermore, the increase in research into the associations between diet and chronic disease has led to an increase in demand for complete, up-to-date and reliable food composition data, and for information on a far greater variety of food components, including bioactive compounds, such as isoflavones, carotenoids and other phytochemicals. Characterisation of these compounds and the levels found in foods therefore represents a whole new challenge for database compilers.

To quote Dr Barbara Burlingame of the United Nations (UN) Food and Agriculture Organisation: “In addressing the diet and chronic disease relationship, two things should be clear: food composition data form the basis by which intakes, and hence diet-disease relationships, are assessed, and food composition data are the fundamental information by which dietary intake goals can be achieved. Without sufficient quantity and quality of compositional data – past, present and future – all diet/disease evidence would be insufficient” (Burlingame 2003).

2.3 Public health and education

Monitoring food and nutrient availability

National governments hold responsibility for monitoring and recording the availability of food and nutrients to their populations, and this is carried out at various levels:

a) Food balance sheets

Food balance sheet information is based on statistical data on the production, import and export of foods and is published quarterly by the UN Food and Agriculture Organisation (see www.fao.org). These data provide a disaggregated picture of food availability at a national level and are converted to energy and nutrient availability to compare national food supplies across countries and over time. These data provide an assessment of the gross adequacy or inadequacy of the national food supply, indicating where there are excesses or shortfalls, but do not provide a precise estimate of actual consumption.

b) Household expenditure surveys

Household expenditure surveys provide data on food expenditure and purchases at the household level that are converted to nutrient availability, so that comparisons of food and nutrient availability within a population can be made by income, region or other household parameters and over time. These types of surveys do not measure food intake directly, only the food entering the household over the study period, but they are an invaluable measure of food purchasing trends over time. Some surveys, e.g. the one conducted annually in the UK, give a more complete picture by also providing data on out-of-home consumption. In this survey, a special coding frame for food purchases has been developed based on the UK food composition tables (see www.statistics.gov.uk/ssd/surveys/expenditure_food_survey.asp).

c) Dietary surveys

Dietary surveys (or food consumption surveys) provide the most detailed estimation of food and nutrient intake at the population level (see below). Sometimes they also provide valuable accompanying data on nutritional status, physical activity levels and dental health. However, these types of surveys are expensive and time-consuming to carry out, so few countries are able to conduct them on a regular basis.

The conversion of food consumption data to nutrient intake data requires an adequate FCDB, regardless of the level at which information on food availability is collected. FCDBs need to be representative of national food supplies, as well as being up-to-date and accessible, in order to be of use in analysis of food and nutrient availability at the national level. Food composition tables that are updated on a regular basis also provide the means to assess long-term changes in the food supply. For example, there have been changes to the fat and iron content of meat in developed countries over recent years, due to changes in animal husbandry and butchering methods (e.g. Higgs 2000). Comparison of current food composition data with past food tables enables changes in the food supply to be explored and monitored (Greenfield & Southgate 2003).

However, changes in the methodology used to assess nutrient levels occur from time to time, as methods are improved and new technology becomes available, and this must be taken into account when examining changes in food composition over time. Furthermore, when compiling past food tables, database compilers may have analysed different varieties or samples (e.g. different varieties of fruit) and used different sample preparation methods (e.g. cooking methods) so the data may not be directly comparable. When examining changes in nutrient composition, therefore, several comparison studies would be required in order to provide evidence of true changes in nutrient levels over time.

Ideally, high quality FCDBs representative of local foods would be developed from scratch for each country or region, but this would be extremely expensive, and therefore many countries (including most developing countries) have to 'borrow' data which they combine with local and regional data to create their own national database. However, the problem with 'borrowing' data from other countries is that local foods do not always have a similar nutrient composition to comparable foods from elsewhere, for which data exist. Also, the particular products available in some countries may be fortified or enriched with specific nutrients, therefore many databases that are currently being used are very limited in terms of their local applicability. For example, vitamin D is added to milk in the US but not typically elsewhere, and therefore US data on the vitamin D content of milk are not applicable to other countries. Similarly, wheat grown in the US has a naturally higher selenium content than wheat grown in Europe, so US data on selenium levels would not be applicable to countries elsewhere.

A useful development would be for countries that maintain the most complete databases to document fully the contribution of fortification to nutrient values, as well as provide modifiable recipes for composite foods, so that appropriate adaptations can be made locally (Harrison 2004).

Public health assessment and dietary surveys

With the growing recognition of the effects of diet on health, many countries have developed national programmes (or dietary surveys) to assess diet and nutritional status at the population level. Dietary surveys aim to provide comprehensive, cross-sectional information on the dietary habits and nutritional status of a population. The results of dietary surveys can be used as a basis for the development of nutrition policies and contribute to the evidence base for government advice on healthy eating.

Dietary surveys carried out in European countries include the Danish National Dietary Survey, the Dutch National Food Consumption Survey and the North/South Ireland Food Consumption Survey. In the US there is a new survey called 'What We Eat in America' which is an integration of two nationwide dietary surveys – the Continuing Survey of Food Intakes by Individuals (CSFII) and the National Health and Nutrition Examination Survey (NHANES). This new integrated survey will be carried out on a continuous yearly basis (a rolling programme).

In the UK, there is a nationwide government survey known as the National Diet and Nutrition Survey (NDNS) (see www.food.gov.uk/science/101717/ndnsdocuments). The aims of the NDNS programme include the following:

- to provide detailed quantitative information on food and nutrient intakes, sources of nutrients and nutritional status of the population under study, as a basis for government policy.
- to describe the characteristics of individuals with intakes of nutrients that are above or below the national average.
- to monitor the diet of the population under study to establish whether it is adequate nutritionally.
- to help determine potential relationships between diet and nutritional status and risk factors for disease in later life.
- to assess physical activity levels in the population under study.

Previously, the NDNS programme surveyed four different age groups separately, with each sample selected to be nationally representative, and collected dietary data via a weighed intake record covering 4 or 7 days, depending on the age group. Dietary data are analysed using the NDNS database, a FCDB that has been developed specifically for the NDNS programme and is continually updated as new surveys are carried out, during survey fieldwork. However, dietary data collection using 7-day weighed intakes is very onerous on participants and response rates on the NDNS have been falling, so changes are about to occur to tackle this. Multiple pass 24-hour recalls will be employed instead to obtain dietary intake data and the survey will become a rolling programme, eventually including individuals across all age groups simultaneously. The survey will probably be carried out on an annual cycle, similar to the model used in the US (see Dwyer *et al.* 2003). These changes will be the subject of a future *EuroFIR* web feature.

In addition, numerous smaller dietary surveys are undertaken in different countries, for example to assess nutritional status at a local level or in specific population sub-groups. These may require food composition data specific to the sub-group being studied (e.g. traditional or ethnic foods). In many countries, these dietary survey programmes have provided the impetus needed for continued support of food composition work.

Development of dietary guidelines

Evidence from epidemiological studies and assessments of nutritional status has led to an increasing amount of information and educational advice on choosing a healthy diet. Reliable and comprehensive FCDBs that are representative of available foods are an essential tool for the development of food based dietary guidelines. The need for good quality nutrient data to improve public health was outlined in the keynote address at the 26th National Nutrient Databank Conference (NNDC) and the Dietary Approaches to Stop Hypertension (DASH) trial that led to the development of the 'DASH' diet to control and prevent hypertension was used as an illustrative example of the importance of FCDBs (Ryan & Champagne 2003).

The DASH trial, carried out in the US, sought to investigate how different dietary patterns (rather than specific nutrients) affected blood pressure. Evidence from previous epidemiological studies, together with clinical trials, had demonstrated that vegetarian dietary patterns are associated with healthy blood pressure levels. This was hypothesised to be due to the fact that vegetables are rich in minerals, such as potassium and magnesium, while also being low in fat and high in fibre, and that these constituents help to lower blood pressure (Harlan *et al.* 1984). Three dietary patterns were compared: The *Average American Diet,* the *Fruit and Vegetable Diet* (providing potassium and magnesium at levels close to the 75th percentile of US consumption) and the *Combination Diet* (also referred to as the 'DASH' diet). The DASH diet provided 9 servings of fruit and vegetables per day, 3 servings of low fat dairy products per day and had reduced amounts of total fat, saturates and cholesterol. It also provided potassium, magnesium and calcium at levels close to the 75th percentile of US consumption and was high in protein and fibre. Each diet provided 3 to 3.5g of sodium per day and the diets were energy adjusted so that respondents maintained their weight while on the trial.

A database known as the MENu (Moore's Extended Nutrient) database was used to design recipes and food items for nine meals for each of the three diets. Meals were then prepared and analysed for their nutrient composition. Based on the food analysis results, the recipes and menus were then adjusted to ensure that the nutrient composition met the targets that had been set. Full details of the methodology used are published elsewhere (see Appel *et al.* 1997). The DASH diet lowered systolic blood pressure by 5.5mm Hg and diastolic blood pressure by 3.0mm Hg, compared to the other two diets. This effect was seen within 2 weeks and continued for the duration of the study (Ryan & Champagne 2003).

The DASH diet has now been endorsed by the American Heart Association (Krauss *et al.* 2000). It has been shown to be effective in both men and women and reduces blood pressure to the same extent as that achieved through medication, as well as being safe and cost effective. However, this could not have been achieved without the availability of food composition data and illustrates the importance of high-quality nutrient databases in public health nutrition research and the development of dietary guidelines for population groups.

Food regulations and food safety

Many public health nutrition decisions depend on the availability of adequate data on the food and nutrient intake of populations in different countries. These include decisions on the enrichment or fortification of foods and on issues of food safety.

Fortification with folic acid

One example of the use of food composition data in the development of public health policy is the issue of folic acid fortification. It is now well recognised that for pregnant women, taking folic acid during the peri-conceptional period can reduce the incidence of neural tube defects (NTDs), such as spina bifida, in the developing fetus and it is currently recommended in the UK that all women who may become pregnant should take a folic acid supplement (400µg/day) prior to and up until the 12th week of pregnancy (DH 2000). However, although there have been several government campaigns to increase awareness of the importance of folic acid supplementation, many pregnancies are still unplanned and, in these cases, women often do not start taking folic acid supplements until it is too late (Buttriss 2004). Furthermore, there is also evidence from national dietary survey data of widespread marginal folate status in the UK population (particularly among young women and the elderly) which could also be addressed with fortification. For these reasons, the statutory fortification of flour with folic acid is currently being debated for a second time in the UK, as well as a number of other countries, including Ireland, Switzerland, Australia and New Zealand (SACN 2005).

There is now evidence from countries that have introduced fortification policies, such as the USA, Canada and Chile, that fortification of flour can reduce the incidence of NTDs by around 27-50%. The UK Food Standards Agency (FSA) has so far not proceeded with fortification, primarily due to concerns about the possibility of masking vitamin B_{12} deficiency anaemia in the elderly population, although the issue is now being reconsidered. The FSA has used food composition data, together with dietary intake information, to model likely folic acid intakes in different groups, should fortification go ahead. The UK government's Scientific Advisory Committee on Nutrition (SACN) has recently published a draft report on folate and disease prevention, which again concludes that there is a need, on balance, for the introduction of mandatory fortification of flour with folic acid in the UK (SACN 2005), reaffirming earlier government advice (DH 2000).

Food safety – example of oily fish

Food safety hazards from naturally occurring compounds or environmental contaminants are another reason why data on the composition of foods are necessary. Several natural food components present safety risks if consumed in excess (e.g. salt and vitamin A) but there are other environmental food contaminants that have been detected in certain foods, such as dioxins and PCBs (polychlorinated biphenyls).

Data on contaminants in foods are limited in most countries and not all laboratories are able to analyse foods for contaminants as well as nutrient composition. In order to estimate exposure for particular subgroups of the population, data on food contaminants (where available) has to be mapped onto food consumption data on intake of particular foods and nutrients, and assumptions made where contaminant data is not available (Harrison 2004).

An example of this is the UK advice on oily fish consumption for the general population that was issued by the FSA in 2004 and included specific advice for certain groups, such as women of childbearing age. This new advice was based on a joint report from SACN and the Committee on Toxicity (COT) which considered the risks and benefits of fish consumption, in particular oily fish (SACN 2004). The current advice for the general UK population is to consume at least two portions of fish per week, one of which should be oily. However, the new advice recommended, for the first time, maximum intakes of oily fish for different groups. For example, pregnant women and those who may become pregnant are now advised to consume no more than 2 portions of oily fish per week.

The basis for these SACN recommendations is that the consumption of fish, particularly oily fish, confers significant health benefits in terms of a reduction in the risk of cardiovascular disease. This is thought to be due to the long-chain *n*-3 fatty acids found in fish, levels of which are particularly high in oily fish. However, the maximum limit on oily fish consumption is due to the risk of exposure to pollutants, such as dioxins and PCBs, which have been found in oily fish. These are persistant compounds that may accumulate over time in the body and could have adverse effects on health if consumed at high levels over a long period of time.

Consumer education

Food composition data are also important for the provision of dietary guidelines and advice on healthy eating for the general population. It is usually the responsibility of national governments to provide healthy eating information for the general public, but this is also carried out by public health charities and non-government organisations, as well as the food industry.

As described earlier (see section 2.1), healthy eating advice in the UK is based on a model known as the *Balance of Good Health*. This is a pictorial food guide showing the proportion and types of foods that are needed to make up a healthy, balanced diet. It is based on the UK dietary reference values for energy and nutrients and is applicable to all healthy adults and children over the age of 5 years. Similar models exist in other countries, such as the food pyramid model used in the US. Such models are used as the basis for healthy eating leaflets and information provided via other media, such as the internet.

Other European countries that have developed their own pictorial food guide illustrations include Germany, Portugal and Sweden. Most European countries use a circular format, similar to the *Balance of Good Health* model, such as the *German Nutrition Circle*. Although there are differences in the shapes and food groupings of different food guide illustrations around the world, the core recommendations are similar – that is that the diet should be based on large amounts of grains, fruit and vegetables, with a moderate intake of milk and dairy products and meat (Painter *et al.* 2002).

The results of epidemiological research (see section 2.2) are used as the basis for the development of more specific guidelines for particular groups of the population (e.g. certain ethnic groups) or government health campaigns to increase awareness about important aspects of the diet, such as limiting salt intake or increasing fruit and vegetable consumption.

Educational materials

Food composition tables and databases are an important educational resource at all levels of education and help in the development of an understanding of the role of foods in the provision of nutrients. However, simplified tables and databases are required for children in younger age-groups.

Within primary and secondary education, food composition data are used to prepare educational materials such as software packages and specialist texts. They are also used in the teaching of subjects such as food

technology and home economics. Within undergraduate and postgraduate education, food composition databases and tables are used in the teaching of courses in a range of nutrition-related subjects, including nutrition and dietetics, public health nutrition, and food science and technology courses.

2.4 Food industry

Increasing levels of international trade have led to a greater need to access data for foods from other countries. For example, governments need to know the composition of imported foods in order to ensure the nutritional value and safety of foods available to the population. Similarly, food retailers and manufacturers need to know the composition of foods or ingredients imported in order to meet food labelling requirements as well as national standards and regulations. Standards such as Codex Alimentarius[1] utilise food composition data at an international level.

Food labelling and nutrient claims

FCDBs are now a widely used source of information for food labelling. Most countries (including European countries) now permit the use of data from an 'authoritative source' for food labelling purposes. Some food manufacturers and retailers carry out their own food analyses, but this is a costly and time-consuming process and therefore the use of data from existing food tables is an alternative method which is much more economical for manufacturers (Southgate 2000).

The Codex Alimentarius Committee on Food Labelling, which is responsible for drawing up internationally agreed standards and codes of practice, has developed uniform methods for the use of food composition data on food

1 The Codex Alimentarius is a collection of internationally adopted food standards, codes of practice, guidelines and recommendations which have been created for the purpose of protecting the health of consumers and ensuring fair practices in the food trade.

labels, emphasising the importance of current and valid food composition information for international trade. Data on the composition of ingredients is critical for predicting the composition of finished products. This information, in turn, is required to verify the nutritional information provided on the label.

In the EU, there is no legal requirement to provide nutritional information on food labels, unless a nutrient claim is made, in which case a specified format is obligatory that provides, as a minimum, information on energy, protein, carbohydrate and fat, per 100g. An alternative format, with 8 nutrients, is also permitted. However, many (and in some countries most) manufacturers now include nutritional information on food packaging voluntarily. Where nutritional information is shown, it is recommended that all the nutrients shown in figure 3 (also known as the 'Big 8' nutrients) are provided, if space permits.

Figure 3: *Example of nutrition panel, showing the 'Big 8' nutrients.*

NUTRITION INFORMATION	**Per 100g**
Energy	1466kJ 347kcal
Protein	10g
Carbohydrate *(of which sugars)*	57.2g 6.6g
Fat *(of which saturates)*	8.7g 1.3g
Sodium	0.4g
Fibre	16.6g

Food composition data are also required to determine whether a nutrient claim can be made on product packaging. Within the EU, a reference to the relative or absolute amount of a nutrient, outside the declarations made within the nutrition panel, is considered to be a nutrient claim. Recommended daily amounts (RDAs) are used on food labels as reference values for selected vitamins and minerals. RDAs are estimates of the amount of vitamins and minerals sufficient to meet (or more than meet) the needs of groups of adults, rather than individuals. RDAs are part of the Nutrition Labelling for Foodstuffs Directive (90/496/EEC) and reflect the variation in opinion across Europe as to the precise values to use. There is only one figure for each nutrient, derived from figures for adults. Table 4 lists the RDAs for vitamins and minerals and also shows the criteria for micronutrient claims.

Table 4: *RDA values and criteria for micronutrient claims*

	RDA	Source claim (1/6 of the RDA)	Rich source (50% of the RDA)
Vitamin A (µg)	800	133	400
Vitamin D (µg)	5	0.83	2.5
Vitamin E (mg)	10	1.7	5
Vitamin C (mg)	60	10	30
Thiamin (mg)	1.4	0.23	0.7
Riboflavin (mg)	1.6	0.27	0.8
Niacin (mg)	18	3	9
Vitamin B_6 (mg)	2	0.3	1
Folic acid (µg)	200	33.3	100
Vitamin B_{12} (µg)	1	0.16	0.5
Biotin (mg)	0.15	0.025	0.075
Pantothenic acid (mg)	6	1	3
Calcium (mg)	800	133	400
Phosphorus (mg)	800	133	400
Iron (mg)	14	3	7
Magnesium (mg)	300	50	150
Zinc (mg)	15	2.5	7.5
Iodine (µg)	150	25	75

There are also international guidelines relating to nutrient claims. The Codex committee on food labelling proposed draft regulations for nutrition claims in 2001 to ensure that nutrition labelling is effective in providing the consumer with information to enable them to make wise food choices. Nutrition labelling should not present information which is in any way false or misleading. It is also a requirement of the Codex guidelines that if a nutritional claim is made, nutrition labelling is adequate. For more information, see the *EuroFIR* monthly web features on *Food Labelling* and *Nutrition and Health Claims* (EuroFIR 2005).

The European Commission announced its intention to review and streamline current labelling legislation in 2004. This is likely to be a long-term exercise with an expected completion date of 2010. The main objectives of the Commission's proposal are to achieve a higher level of consumer protection as well as to increase legal security for economic operators, to ensure fair competition in the area of foods and to promote and protect innovation in the area of foods. By adopting rules that regulate the information about foods and their nutritional value appearing on the label, consumers will be able to make informed and meaningful choices. This also contributes to a higher level of protection of human health.

The labelling of foods with nutritional information is now widespread and indeed mandatory in some countries (e.g. most pre-packaged foods in the USA). This development has largely been driven by the demand for point-of-purchase information to ensure that consumers can make informed choices. The use of food composition data from national FCDBs for food labelling purposes has not only expanded the user base, but has also had implications for the production of databases, since it strengthens the need for current, reliable and representative data. This has influenced research into, as well as the presentation of, food composition data in most European countries (Church 2005).

Product development and reformulation

When developing new products, food regulators may use food composition data as a reference point for desirable levels of nutrients in the new product. For example, it may be considered desirable that a newly formulated dairy product should provide similar levels of calcium and riboflavin to a similar, traditional dairy food. New food processing techniques should not significantly adversely affect the nutritional quality of a well-recognised product (Greenfield & Southgate 2003). Food manufacturers and retailers are constantly developing new ranges of products. Food composition data are particularly relevant to the development of 'healthier' ranges of processed foods which must meet certain specifications on the amount of fat, sugar and/or salt they contain. Analytical data on food composition are also used to help formulate foods that are fortified with certain levels of nutrients, such as certain breads and breakfast cereals.

Furthermore, existing products are often reformulated to improve taste or to meet certain nutritional criteria. For example, food manufacturers and retailers have recently been working towards reducing the levels of salt in many of their products (e.g. soups, ready meals, meat products) to meet government targets. National food composition tables and databases, therefore, need to be constantly updated to reflect changes in product composition as well as new novel ingredients (e.g. polyols and novel oligosaccharides) and this is very difficult to achieve. Few national authorities have the resources to keep up-to-date with all the developments/advances in the current food supply.

Consumer information and marketing

There has been a growing interest in food and nutrition amongst consumers over recent years and this has been a motivating force behind food manufacturers and distributors providing more information on the nutrient content of their products. Within the food industry, the use of data on food composition is critical to enable food producers to meet consumers' needs. Consumers are particularly interested in information on the composition of children's foods, but there is also a demand for information in relation to the prevention of diet-related diseases, such as cardiovascular disease and different types of cancer. There is also increasing concern over weight control and the prevention of obesity and consumers are now demanding more information, particularly on the fat, sugar and salt content of foods.

Food manufacturers and retailers, in turn, use information on the nutritional composition of foods to market and promote their products, through nutrition and health claims. Nutrient claims, such as 'low in salt', 'reduced fat', 'no added sugar', 'high in fibre' or 'source of folic acid' are often seen on packaging and are used to inform consumers and encourage them to choose one product over another (see above for more information on nutrient claims). Furthermore, food manufacturers often provide further information on the nutrient composition of their products on company websites, together with more general information on diet and nutrition.

Health claims are statements about the beneficial effects of a food or its ingredients on the body, although there is dispute regarding how far health claims can go. Manufacturers are developing products that may have health benefits beyond the provision of nutrients for general health and wellbeing and are drawing attention to this through health claims on the front of food packaging. Examples include n-3 fatty acids and heart health, probiotics and gut health, and the cholesterol lowering properties of soya protein. There is currently no specific legislation about health claims in the EU (although they are covered in the general labelling regulations), but the law states that any claim must be true and not misleading. Labels are not allowed to claim that food can treat, prevent or cure any disease or medical condition, as these are considered to be 'medicinal claims'. There are also Codex guidelines which are followed by many other European countries, and a European Directive is now at an advanced stage. For further information, see the *EuroFIR* monthly web feature on *Nutrition and Health Claims* (EuroFIR 2005).

2.5 Other uses

Consumer uses

Many consumers have an interest in food, nutrition and health related matters, particularly issues around weight control, and a wide range of booklets and guides are now available which show the calorie content of foods. Some guides also show the fat content of foods and possibly other nutrients as well. These guides are based on national food composition data, as well as data from manufacturers on the calorie content of commonly consumed products.

Food composition information is now more widely available to consumers in some countries through the use of portable computer technology. New software can now be used to enable consumers to find out the nutrient composition of foods and learn how food choices affect their nutrient intake (Harrison 2004). These products are likely to become more popular in the future with increasing concern amongst consumers about how diet affects health and the subsequent demand for more information about the nutritional composition of foods.

Food service industry

The food service industry includes catering companies that provide meals for schools and other institutions, as well as cafeterias, restaurants and hotels. As the links between diet and health have become increasingly recognised, consumers are becoming ever more concerned with their diet and looking for healthier options when eating out. There is therefore an increased demand on chefs and caterers to provide healthier meal options within schools, workplace cafeterias and restaurants. Within the catering industry, food composition data is used for menu planning and recipe analysis to provide meals that meet certain nutritional criteria. For example, caterers may want to develop recipes and menus that meet certain recommendations for energy, salt, fat or saturates. Specialised dietary analysis software that is user-friendly has been developed for this purpose e.g. *Saffron Nutrition* (see www.fdhospitality.com/software-solutions/saffron-nutrition.php).

There is also an increased demand on food companies that supply food products to the catering industry, to provide more information on the nutritional composition of their products. There is an increased requirement for products that meet certain nutritional criteria (e.g. lower in salt, fat or saturates) and again, specialised software packages are now available to enable catering companies to calculate the nutritional composition of their products.

Planning of institutional diets

Food composition data have also become increasingly important for planning institutional diets as the links between diet and health have become ever more recognised. Large groups of the population are provided with food in this way, for example in hospitals, prisons, military establishments, schools and day-care centres. In the case of the armed services, FCDBs may be used to develop ration scales for troops and expeditions.

There has recently been an increased focus on school meals as concerns over children's diets and health (particularly obesity) have grown. In Scotland, for example, the government has now introduced nutrient-based standards for school meals under the *Hungry for Success* scheme. Specialised nutritional analysis software is now in use to help school caterers to plan meals that meet these guidelines, for example, a software programme known as *Nutmeg* is currently being used in Scotland. New standards for school meals in England, which are both nutrient and food-based, are due to be introduced in 2006 (see Buttriss 2005).

Sports nutrition and expeditions

Food composition data are also used within the sports and fitness industry to help plan diets for athletes and sports professionals. Athletes need to increase their energy and nutrient intake to meet the extra demands placed on them by intensive sports activities. This increased food intake should be nutritionally balanced and particular attention paid to carbohydrate and fluid intake. This is not always straightforward and requires careful dietary planning. Without good nutrition, athletes will not be able to meet their full potential (see BNF 2001). Moreover, FCDBs may also be used to plan food requirements for endurance expeditions, such as transatlantic and round-the-world boat races.

3. Limitations of Food Composition Databases

The limitations of food composition tables or databases are often poorly understood by users. All foods are biological materials and therefore show natural variability in their composition. This variation may be due to differences in the animal or plant species assessed, environmental factors (e.g. soil and climate), variations in agricultural practices or the storage, processing and preparation of foods. Even processed foods which are produced under very controlled conditions show some variability due to differences in the composition of ingredients and variations in processing, packaging and storage.

The degree of variation in nutrient composition also varies for different nutrients. Micronutrient (vitamin and mineral) values vary more widely than macronutrient (carbohydrate and protein) values, with the exception of fat, which is extremely variable, particularly in meats where the lean to fat ratio can vary widely. Vitamin C and folate show wide natural variability in foods and are particularly unstable, levels being affected by both heat and light. This is such that FCDBs can only give an approximate or typical indication of the levels of these nutrients (Southgate 2000). This therefore limits their usefulness for both scientific and regulatory purposes.

Widdowson and McCance once wrote: “There are two schools of thought about food tables. One tends to regard the figures in them as having the accuracy of atomic weight measurements; the other dismisses them as valueless on the grounds that a foodstuff may be so modified by the soil, the season, or its rate of growth that no figure can be a reliable guide to its composition. The truth, of course, lies somewhere between these two points of view.” (Widdowson & McCance 1943).

In addition to the nutrient content of foods, there is now increasing interest in the potential health benefits of phytonutrients or bioactive compounds, found in many plant foods, e.g. isoflavones and carotenoids. Emerging data from *in vitro* and animal studies suggests that these compounds may play a role in the prevention of chronic diseases, such as cardiovascular disease and some types of cancer. However, most national databases contain little, if any, data on bioactive compounds and therefore it is difficult to assess intakes in human epidemiological studies and relate these to health outcomes.

Furthermore, over recent years, there has been a substantial increase in the amount of manufactured foods consumed and one of the biggest challenges for compilers is keeping databases up-to-date with new products. In addition, as already discussed (section 2.4), product formulations are constantly changing so data on existing products needs to be updated on a regular basis. However, it can be very difficult for database compilers to keep up with the pace of change in the food industry and it is therefore likely that estimates of nutrient intake are becoming increasingly less representative of actual nutrient intake (Greenfield & Southgate 2003).

4. Future Developments and the EuroFIR Project

Diets worldwide have changed dramatically since food composition data were first produced. The food supply is now more dynamic than ever. Trade is undertaken on a global level, which has major implications for the foods consumed within each country. For example, exotic fruit and vegetables and indeed new varieties of indigenous produce, are now commonly available around the world, often all year round. The diverse ethnic populations in many countries have brought with them their own food cultures, and increased the diversity of food outlets in the countries to which they have migrated. Processed foods are now widely consumed and the variety of available products is continually increasing. New ingredients and new processing methods have been developed and, more recently, there has been increasing interest in functional foods (Church 2005).

Food composition data are currently being used in multi-centre studies and in ways which were not previously anticipated (e.g. within specialised fields of health, agriculture, environmental sciences and economics). Furthermore, environmental events such as diminishing crop biodiversity, the development of genetically modified organisms and climate change will also require the attention of database compilers. Key aspects that need to be re-examined include the representativeness of foods, the completeness of FCDBs (i.e. the need to generate data for missing foods) and an integrated approach to FCDB development internationally (see Burlingame 2004).

Although their have been major efforts over the past two decades to standardise food descriptions, nutrient terminology, analytical techniques and compilation methods, nutrient values in different FCDBs are still not readily comparable across countries (Greenfield & Southgate 2003). Several recent initiatives from the European Commission, such as FLAIR (Food-Linked Agro-Industrial Research) and INFOODS (International Network of Food Data Systems) have so far led to greater collaboration between European countries, but there is still a lack of permanent structures to support this type of work and relatively poor links between the various national database compilers, policy makers and end-users of the data.

Europe urgently needs a single, accessible and reliable food composition information resource in order that the relationships between dietary intakes and health can be further explored and the burden of chronic disease and associated health and social costs reduced. A single, comprehensive and validated FCDB will enable the full interpretation and exploitation of research findings from pan-European studies and effective dissemination to various stakeholders such as consumers, the food industry, educators, policy makers and health professionals.

EuroFIR (short for 'European Food Information Resource Network') is a five-year project funded by the European Commission through the EU Sixth Framework Programme. The main objective of *EuroFIR* is to develop an integrated, comprehensive and validated databank or *food information resource* which will provide a single, authoritative source of food composition data in Europe for nutrients and newly emerging bioactive compounds with potential health benefits. This objective is an essential underpinning component of all food and health research in Europe.

EuroFIR is a partnership involving 40 universities, research institutes and small-to-medium sized enterprises (SMEs) from 21 European countries. The main aims of the project include:

- strengthening the scientific and technological excellence in food databank systems and tools in Europe.
- identifying and providing new information on missing data for nutrients and bioactive compounds for all food groups, including traditional and ethnic foods.
- training a new generation of European scientists in the development, management and application of food databank systems.
- communicating with all user and stakeholder groups to develop food databank systems for the benefit of European food and nutrition research.
- disseminating and exploiting new scientific and technological knowledge to create a sustainable and durable body.

As a Network of Excellence, *EuroFIR* aims to address some of the problems that have hindered the development of a pan-European database in the past, including developing partnerships with the private sector, thereby helping to accelerate the progress of nutrition and health research. The *EuroFIR* Network has an important role in supporting the development of FCDBs and ensuring their future viability, as well as providing guidelines for and supporting national database compilers (Church 2006).

For further information, see the *EuroFIR* website: www.eurofir.net

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