REVIEW

The history of food composition databases

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Summary

Food composition databases provide detailed information on the concentrations of nutrients and nutritionally important components in foods. Information on the nutritional composition of foods forms the basis of the quantitative study of nutrition, and is widely used in a variety of fields, including epidemiological research, clinical practice and health promotion, policy and food manufacturing. This review details key milestones in the development of food composition databases, focusing on the history of the well-known and highly regarded *McCance and Widdowson's The Composition of Foods* series. Evolving requirements for food composition data are outlined together with changes in the format over time. Finally, the importance of networks and cooperations, such as the new European Food Information Resource (EuroFIR) Network of Excellence, in supporting and improving food composition data is discussed.

Keywords: food composition, history, nutritional value, nutrient databases

Introduction

Food composition databases provide detailed information on the concentrations of nutrients and nutritionally important components in foods. They have a wide variety of uses, which includes:

- assessment of health and nutritional status at individual, regional, national and international levels;
- formulation of appropriate institutional and therapeutic diets, including those for schools and hospitals;
- helping to identify nutrition education and health promotion needs;
- food and nutrition training;
- epidemiological research on relationships between diet and disease;
- devising nutrition labelling;
- food product and recipe development;
- monitoring the nutritional value, safety and authenticity of foods for food trade, and consumer protection and information;
- improvements to the food supply, such as plant breeding and new methods of cultivation, harvesting and preservation.

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Key events in the development of food composition databases

First milestones

It is likely that the first food composition table, in the form of a 'nutrition scale', was produced as early as 1818 (Percy & Vaquelin 1818; Somogyi 1974). This appears to have arisen from investigations in connection with the food supply in prisons.

Food composition tables in the format known today, however, were not published until the end of the 19th

century. The first European food composition table was published in Germany in 1878 (Konig 1878).

Early American tables

Perhaps, more widely known among the earliest tables are those published in the United States in 1896 (Atwater & Woods 1896). These tables incorporated nearly 2600 analyses of a wide range of foods from the main food groups (*e.g.* meats, cereals, fruits and vegetables) and also some processed foods such as chocolate, sausages and crackers. Values were presented for 'refuse', water, protein, fats, carbohydrates (calculated by difference, as the amount left after subtracting the amount of water, protein, fat and ash from the weight of the food), ash and 'fuel value'. A later edition (Atwater & Bryant 1906) also included separate crude fibre values.

Food and Agriculture Organization (FAO) tables for international use

An interesting milestone in food composition databases was the publication of 'Food Composition Tables for International Use' by the FAO in 1949 (Chatfield 1949). These tables were produced in order to assist in the assessment of food availability at the global level, including calculation of energy, protein and fat availability, on a per caput basis, using Food Balance Sheets.

European milestones

As well as the UK, many other European countries were also early pioneers in the field of food composition. Details of the development of food composition databases in a range of European countries have been summarised elsewhere (Church 2005; http://www.eurofir.net). Some of the earlier European 'official' food composition tables include those published in The Netherlands (van Eekelen *et al.* 1941) and Italy (Istituto della Nutrizione 1946). In addition, food composition research and publications can be traced back to the late 19th century in some European countries, *e.g.* Denmark and Sweden.

History of the British food composition tables – a case study

Although the UK has been widely seen as a leader in the field of food composition databases, the first UK developments came many years after tables had been produced in Germany and the United States (Widdowson 1967, 1974; Southgate 1993). Work in the UK can be traced back to the First World War (1914–18), when concerns over food shortages led to the British War Office directing Captain Plimmer, a chemist serving in the Army, to undertake analyses of common British foods. Values for water, ash, protein, carbohydrate (sugars analysed, starch calculated) and fat were determined, in duplicate where possible, for 900 foods. In addition, many foods were analysed for their fibre and sodium chloride content. The resulting tables were published in 1921 (Plimmer 1921).

About this time, Dr R. D. Lawrence, of King's College Hospital, London, and R. A. McCance, a medical student, became interested in the treatment of people with diabetes and in the calculation of food values of fruits and vegetables, which were the mainstay of diabetic diets in these early days of insulin availability. There were a number of problems with the existing carbohydrate values, and in 1925 McCance was awarded a grant by the British Medical Research Council, which enabled him to analyse cooked and raw fruits and vegetables for available carbohydrates (McCance & Lawrence 1929). The importance of direct determination of carbohydrates, rather than calculation 'by difference', is a principle still followed in British food composition studies.

This work was extended to a detailed study of the composition of meat and fish, including protein, fat and minerals (McCance & Shipp 1933). Elsie Widdowson joined the team as a new study on fruits and vegetables began, extending the previous work on carbohydrate content to protein, fat and minerals (McCance *et al.* 1936). From her contacts with dietitians and the dietary surveys that she had undertaken, Widdowson (1967) realised the need for comprehensive tables of the composition of British foods. Analyses were therefore further extended to cereal foods and dairy products, and to items such as beverages, preserves and confectionery. All the analyses were brought together in the first edition of what later became *The Composition of Foods* (McCance & Widdowson 1940).

Unusually for that time, the tables included the composition of many cooked foods and cooked dishes, the latter being derived by calculation together with recorded weight loss on cooking. In addition, rather than analysing each sample of food individually and then calculating an average, one composite sample (which included a number of different sub-samples) of each food was analysed. This approach reduced the amount of work required and, while not giving information about variation, provided representative figures for the food.

The nutrients and components in this first edition included water, available carbohydrate, sugar, starch

and dextrins, unavailable carbohydrate, total and purine nitrogen, protein, fat, energy (kilocalories), inorganics (sodium, potassium, calcium, magnesium, iron, copper, phosphorus, sulphur and chloride), edible matter and acid-base balance.

The second edition followed in 1946, incorporating foods consumed during the war and post-war years (McCance & Widdowson 1946). The third edition (McCance & Widdowson 1960) was extended to include the processed foods that were becoming increasingly important in the diet, and also values for vitamins and amino acids. About 100 new foods were analysed. However, because of the wealth of information already available on the vitamin content of foods, it was decided to include previously published values in the database for the first time, rather than analysing every food for every vitamin.

A partnership between the Medical Research Council, the Ministry of Agriculture, Fisheries and Food (MAFF) and the Laboratory of the Government Chemist (for analyses) was formed to produce the fourth edition (Paul & Southgate 1978). This edition was needed primarily because of the constantly evolving and increasingly diverse diet of the UK population, and the many new or improved processed food products available. Work on this edition was led by David Southgate and Alison Paul, with Elsie Widdowson still keeping an active interest, providing continuity of the sound principles on which the tables are based. In recognition of their special contribution to nutrition composition research, McCance and Widdowson's names were incorporated into the title of this and subsequent editions of the tables.

The fourth edition was prepared with computerised databases in mind, and for the first time, a computer-readable tape was made available at the same time as the printed book was published in 1978 (A few researchers had also produced computerised versions of the third edition, primarily for their own use.). Although the 28 reels of paper tape required further editing by users (Day 1985), they were another important milestone in the evolution of the tables, and marked a gradual move away from printed tables to electronic formats, including nutritional analysis software.

Following the publication of the fourth edition MAFF, and subsequently the Food Standards Agency on its formation in 2000, took on responsibility for maintaining and updating the UK food composition tables. The fifth and sixth summary editions (Holland *et al.* 1991; Food Standards Agency 2002), and a range of food-group specific (*e.g.* fruits and nuts) and other nutrient-specific supplements (*e.g.* fatty acids) (details given in Food Standards Agency 2002) were published.

Evolving requirements for food composition tables

'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 often quoted remark 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 (Greenfield & Southgate 1992, 2003). Such studies remain central to nutrition research into the role of food components and their interactions with health and disease, but at an ever-increasing level of sophistication and complexity.

The evidence from epidemiological studies and national assessments of nutritional status have led to increasing guidance and education programmes on choosing a healthy diet. Food composition data provide the foundations for such guidance, which includes nutrition labelling information.

Nutritional issues related to specific diseases, population sub-groups or specific situations were an early driver for studies on the composition of foods. Use of food composition data in the development of therapeutic diets (*e.g.* to treat obesity, diabetes, nutritional deficiencies, metabolic disorders, food allergy and intolerance) has been facilitated by advances in information technology and, in particular, the production of nutritional analysis and meal planning software. Food composition data have also become increasingly important for planning institutional diets (*e.g.* schools, hospitals, prisons, day-care centres), as the links between diet and health have been recognised. Recent examples include the focus on school meals, as concerns over children's diets and health (*e.g.* obesity) have grown.

Nutrition labelling of foods is now common, and is indeed mandatory in some instances. This development has largely been driven by the demand for point-of-purchase information to ensure that consumers can make an informed choice. The use, where appropriate, of 'authoritative' composition data taken from compilations, such as national food composition databases, is often permitted as an alternative to direct analyses of products, in order to calculate nutrient values for food labelling purposes. This is the case in

Europe. As well as hugely expanding the user base for food composition databases, this development has also had implications for the production of databases, as it strengthens the need for current, reliable and representative data. This has influenced research into, and the presentation of, food composition data in most European countries.

Changes in the format of food composition tables

Printed tables

Food composition tables were originally produced in print, which for many years remained the only format.

Food composition tables that have been produced, or are available in Europe, are listed on the International Network of Food Data Systems (INFOODS) website (http://www.fao.org/infoods/tables_europe_en.stm). An inventory of European food composition databases and tables was also compiled as part of the COST Action 99 and can be found at http://www.langual.org/langual_literature.asp.

Electronic formats

Although printed tables are still produced in most countries, computerised databases have become increasingly important because they can hold large amounts of data and allow easy access to, and manipulation of data. Electronic formats range from ASCII (plain text) and spreadsheet formats on disk to CD-ROMs and databases with online access. The British food composition tables were first made available on computer-readable tape in 1978. The US tables have been available online since 1996.

The LanguaL website currently provides information on databases available online, together with their associated links (http://www.langual.org/langual_linkcategory.asp?CategoryID=4&Category=Food±Composition).

This information will also be made available on the European Food Information Resource (EuroFIR) website in the near future (http://www.eurofir.org/foodlinks/), and will be regularly updated.

Added-value products

As well as official versions of food composition tables in printed and electronic formats, there are many other products based on, or dependent on, food composition data. Products are aimed at a wide spectrum of users, including consumers, health professionals and caterers. These include:

- abridged versions of tables, traditionally in printed format, but more recently also for online access (*e.g.* calorie and carbohydrate counters);
- user-friendly formats (*e.g.* expressed per portion; in formats suitable for nutritional labelling);
- nutritional analysis software – a wide range of products, including products aimed at health professionals, education, food industry (labelling and product development) and caterers (menu planning);
- online nutritional analysis – more common in the United States but also available in Europe;
- novel products (*e.g.* food weighing scales that incorporate calorie counters).

Networks and cooperations

Food composition databases have generally been compiled as independent national activities to meet local requirements for calculating nutrient intakes. As a result, it has been difficult to use national datasets internationally, and the results of costly food analysis programmes have not been fully exploited at an international level. There is, however, an increasing requirement for internationally compatible information. For example, with increasing international trade, there is a greater need to access data for foods from other countries. In addition, poor comparability between data in European countries impacts upon the ability of researchers' to undertake meaningful multi-centre nutritional epidemiological studies (Deharveng *et al*. 1999; Charrondiere *et al*. 2002), and prevents the food industry from understanding and exploiting their products in the marketplace.

The recognition of the need to improve compatibility has led to the development of a number of cooperations and networks over the last 25 years.

INFOODS

INFOODS was established in 1984 to stimulate and coordinate efforts to improve the quality and availability of food analysis data worldwide, and to ensure that anyone anywhere would be able to obtain adequate and reliable food composition data (*via* the INFOODS website). From 1994, INFOODS was co-sponsored by the FAO of the United Nations, and since 1999 the secretariat has been based at FAO in Rome (http://www.fao.org/infoods/).

INFOODS activities include the provision of leadership and an administrative framework for the development of standards and guidelines for collection, compilation and reporting of food component data, and

the establishment and coordination of a global network of regional data centres directed toward the generation, compilation and dissemination of accurate and complete data on food composition. INFOODS also initiated work to produce guidelines on the production, management and use of food composition data (Greenfield & Southgate 1992, 2003).

Eurofoods and FLAIR Eurofoods-Enfant Project

A group of scientists, led by Dr Clive West, established Eurofoods in 1982 in recognition of the need to improve compatibility of food composition tables and nutrient databanks in Europe (West 1985). In 1988 it was agreed to extend the work to food consumption and nutrient intake, and after the successful submission of a European Commission proposal, the FLAIR Eurofoods-Enfant Concerted Action project, which ran from 1990 to 1994, was established. The objective of the project was to establish a comparable and compatible system of high-quality data on food consumption and food composition.

COST Action 99

COST is an acronym for 'European cooperation in the field of scientific and technical research'. COST Action 99: 'Research action on food consumption and composition data' began in January 1995, ended in 1999 and included participants from 25 European countries (COST Action 99 website: http://food.ethz.ch/cost99/main.htm), which was the largest participation at that time for a COST Action. It was a continuation of Eurofoods and the FLAIR Eurofoods-Enfant Project, and worked towards improving the quality and compatibility of data on food consumption and composition in COST countries.

The European Food Consumption Survey Method (EFCOSUM)

The EFCOSUM project was undertaken within the framework of the European Union (EU) programme on Health Monitoring between 1999 and 2001. A total of 23 European countries participated, and the aim was to define a method for monitoring food consumption in nationally representative samples of all age–sex categories in Europe in a comparable way. One of the four topics covered was comparability of food composition tables (Ireland *et al*. 2002). The aim of this work topic was to harmonise food classification and food composition databases, allowing comparability of consumption at both food and nutrient levels in Europe. It was concluded that the establishment of a European nutrient databank is a necessity for conversion of foods to nutrients (Brussard *et al*. 2002).

Where are we now?

The outputs from COST Action 99 are being used in the initial documentation of national food composition datasets, with limited funding and on an *ad hoc* basis. However, these recommendations need to be further tested and extended, to provide a basis for the comparison of data in the various European national datasets and their integration into a consistent, readily available information resource.

A number of underlying issues in the past have hindered the development of a single comprehensive food composition database for Europe. These include the lack of permanent structures to support those involved in developing and maintaining food composition databases, lack of national support, and the relatively poor links between the various national database compilers, end-users of the data (*e.g.* the food industry, public health nutritionists and European consumers) and policymakers.

EuroFIR

EuroFIR, the world-leading European Network of Excellence on Food Composition Databank Systems (http://www.eurofir.net), is a partnership between 40 universities, research institutes and small to medium-sized enterprises (SMEs) from 21 countries. EuroFIR aims to develop and integrate a comprehensive, coherent and validated databank, providing a single, authoritative source of food composition data for Europe.

As a Network of Excellence, EuroFIR aims to address the weaknesses that have hindered the development of such a database in the past, thereby accelerating the application of research results to policy and health developments, as well as developing partnerships with the private sector. Networks such as EuroFIR have an important role in supporting food composition databases and ensuring their future viability, as well as in providing guidelines for and supporting national food composition database compilers.

Conclusion

In conclusion, quantitative data on the composition of foods are essential for most quantitative human nutrition research and for the development of food and nutri-

tion policies at the national and international level (Greenfield & Southgate 2003). The importance of food composition research is not always recognised by funding bodies, but it is vital that food composition databases continue to be maintained and developed.

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