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The compilation of food analysis values as a database for dietary studies—the Finnish experience

Marja-Leena Ovaskainen,* Liisa M. Valsta & Jukka Lauronen

National Public Health Institute, Department of Nutrition, Mannerheimintie 166, FIN-00300 Helsinki, Finland

In dietary studies the food composition data are needed for assessing intake of study subjects. A database for this purpose should include content for foods as consumed, i.e. the database should include brands and dishes described by recipes. The progress made in developing the national Finnish food composition database for dietary studies at the National Public Health Institute is presented. The usefulness of a relational database model in database maintenance is considered and some gaps (e.g. missing foods and retention factors for loss) are discussed. As future challenges, setting priorities in analysis needs, co-operation on food description as well as on nutrient identification are emphasized. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

Food composition databases are used in dietary studies to calculate nutrient intake in a study population. For the purposes of epidemiological studies a growing need for better and more comprehensive food composition data has been obvious. The question of data quality—'fitness for the purposes for which it will be used' (Southgate, 1995)—is essential. The sampling and analytical procedures must be assessed in light of the research objectives at hand. We need to recognize the limitations of existing procedures in the database compilation as well as in the sampling. The purpose of this presentation is to describe the state of the Finnish Food Composition Database, the progress we have made in developing this national resource at the National Public Health Institute and the challenges we still encounter especially in co-operation with other European countries and in multinational studies.

FLOW OF FOOD COMPOSITION DATA FROM THE LABORATORY TO THE DATABASE MAINTAINER

The Finnish Food Composition Database started to get more specified content data and to expand widely in 1980. Both the number of nutrient factors and food items has since increased. The Finnish Food Composition Database now includes 800 basic food items with analysed or derived nutrient values and 1200 dishes composed by recipes. Identification and better description of food items has been a continuous task for the database compiler. Much effort has also been put into identifying correctly nutrient factors analysed by different methods. The first of the new analysis series was a comprehensive study on the mineral element composition of Finnish foods (Koivistoinen, 1980). Since then, studies on dietary fibre (Varo *et al.*, 1984), tocopherols and tocotrienols (Piironen, 1986), carotenoids and retinoids (Heinonen, 1990), and fatty acids (Hyvönen *et al.*, 1993) have been published. Analytical techniques recognized as being suitable for food composition analyses (Greenfield & Southgate, 1992) have been used. The results from the Finnish laboratory were evaluated in an interlaboratory study (Hollman & Katan, 1988).

The flow of nutrient composition values from food chemistry laboratories to food database compilers includes various specifications (descriptions of food sample, food source, physical state and volumes used). Thus, there are guidelines and standards to ensure food identity when entering composition values into the database. To facilitate food identification internationally a specific food vocabulary exists, originally developed in the 1980s by the US Food and Drug Administration (FDA). Later, this system has been

*To whom correspondence should be addressed.

Table 1. Total amounts of nutrient values, proportions (%) of analysed and other data in the Food Composition Database of the National Public Health Institute

	Total number of values (*n*)	Analysed (%)	Calculated[a] (%)	Literature (%)	Derived[b] (%)	Missing (%)
Tocopherols (eight compounds)	4690	29	2	8	44	17
Retinoids/carotenoids (seven compounds)	4100	32	2	8	45	13
Fatty acids (70 isomers)	45700	42	—	8	40	10

[a]Using a mathematical formula.
[b]Using a recipe or a similar product

developed further by the Centre Informatique sur la Qualité des Aliments in France as LanguaL (Feinberg *et al.*, 1992). The characteristic features of food items can be presented in tables like facets for food coding. LanguaL has not been used in Finland so far for food identification, but the facets used in the database resemble LanguaL coding.

Altogether, the number of nutrient factors in the Finnish Food Composition Database is today above 200. The database includes energy and energy nutrients, 10 vitamins, fatty acids (70 isomers), cholesterol, carbohydrate and dietary fractions (14), minerals and trace elements (25), and other dietary components (retinoids, carotenoids, tocopherols, tocotrienols, nitrates, nitrites and some heavy metals). Almost half of the nutrient values in the most recent analysis series are based on direct analytical values (Table 1). The values derived by recipes are mostly based on analytical values of a similar product. However, it is obvious that each country needs a flexible, adaptive programme for food analysis because of the growing number of food products available in food stores, new farming practices and new formulation practices in food manufacture. The Finnish Food Composition Database is maintained at the National Public Health Institute. For database compilers it may be easier to collect analysed values from one or two laboratories than from several laboratories. In Finland the main sources of the analysed composition values are the Divisions of Food Chemistry at the University of Helsinki and at the Agricultural Research Centre of Finland.

The entity–relationship model (relational database) is used in data maintenance at the National Public Health Institute. The model of food information is based on the principle that the world of foods can be perceived as a collection of objects (entities) and that these objects stand in certain relationships to one another. In the Food Composition Database the most relevant entities are foods, nutrient factors and nutrient values. Each food may have several values for a given nutrient, e.g. selenium and sodium. It has been necessary to separate nutrient factors by time or by analytical method. International guidelines for identification of food components (Klensin *et al.*, 1989) has been used in Finland during the last years. Each nutrient is identified by name, popular name, tagname, unit, etc. One nutrient may be combined with several analysis series, reflecting changing methods and changing values over time.

Dietary fibre may be taken as an example of handling methodological differences in the database. There are some analysed values for dietary fibre of Finnish food items obtained by two methods. Varo *et al.* (1984) determined the total dietary fibre by the Englyst method and Plaami *et al.* (1992) by the method recommended by AOAC. The measured values for Finnish vegetables and fruits were similar by both methods. However, both values must be entered—if available—and separated from each other by definition in the database because of the methodological differences.

To illustrate with an example what questions may arise in the compilation of food composition database, it is not obvious how one should measure intakes in dietary studies. Should the total intake of all carotenoids or only the non-A carotenoids be computed? Should vitamin A precursors be regarded solely as vitamin A equivalents? It is well known that even the most common carotenoid, β-carotene, has other effects besides vitamin A activity. Further analysis of the diet among Finnish adults (Kleemola *et al.*, 1994) shows that β-carotene, lycopene, and lutein and zeaxanthin are the main carotenoid compounds found in the Finnish diet (Table 2). Two proposals for the evaluation of carotenoid intake would be to calculate: (1) the intake of vitamin A carotenoids and intake of non-A carotenoids; or (2) the intake of oxygen-containing carotenoids and intake of non-oxygen-containing carotenoids. Either type of information may be of theoretical interest. Thus, how we express carotenoid intake depends on the particular aims of each study.

Table 2. Carotenoid intake of Finnish adults

	Intake (μg/day) Men	Women
Vitamin A (RE)	1559	1353
Retinol	1159	886
Carotenoids (RE)	401	467
Total intake of carotenoids	4723	5008
α-Carotene	122	152
β-Carotene	2262	2646
γ-Carotene	51	55
Lycopene	996	1049
Cryptoxanthin	7	8
Canthaxanthin	45	44
Capsanthin	62	118
Lutein, zeaxanthin	1403	1236

DIFFICULTIES IN THE DATABASE MAINTENANCE

The Food Composition Database should be comprehensive, complete and current for the purposes of epidemiological studies. Information on all nutrients and other constituents of foods is needed, the database should have values for each food, and an updated food composition data should reflect the changing food market. One of the basic questions is what principle has been selected for food sampling. The Finnish database includes a great number of nutrient factors, although, for example, amino acids and flavonoids are still missing. For all composition values the missing information includes the range and variation. The reason for this is that in the analytical procedure used by the main information producer at the University of Helsinki, samples have been pooled from subsamples of commercial products (Heinonen, 1990). For each pooled sample the composition analyses were carried out in triplicate, but individual subsamples were not analysed. This approach is inexpensive and has, so far, been adequate because of the homogeneity of Finnish foods but gives no information on real variances.

Striving for the most comprehensive and current values of dietary components is a good goal, but in practice some compromises have to be made. For which foods do we need analysed values? To make this decision we should evaluate results of national dietary surveys. The most relevant food items for each subgroup should be re-evaluated after each survey, changes in composition recognized, current analyses planned and the recipes for most common dishes taken into consideration. The Finnish Food Composition Database includes many dietary components and values from recent years but we, no doubt, have to ask for which nutrients do we need better data and which nutrients have the highest priority. For database compilers the elimination of missing values may be as problematic as the elimination of thousands of foods, brands and dishes. When the number and specificity of dietary components has increased as much as it has in Finland the maintenance of nutrient values is difficult, expensive and labour-intensive.

In dietary studies nutritionists typically ask what foods subjects put on their plates, that is, how they composed their meals out of the food items that they took home from the supermarket. When converting the information obtained into nutrient intake, researchers must take into account the nutrient composition data of commercial food items as well as the recipes used for preparation in homes. As an example of changes in composition a typical Finnish dish, meatballs, can be considered. The meatballs consumed by adolescents tend to be quite different from those consumed by retired people, because adolescents usually eat industrial meatballs, whereas retirees more often prepare meatballs at home based on old-fashioned recipes. The food composition database must have information on both types of this dish. Both include pork and beef, but industrial meatballs also include soy flour, potato and egg yolk, while home-made meatballs include cream and whole eggs. It is obvious that the resulting fat content is rather different. If we do not have adequate specifications here, our data are bound to be inadequate.

In reality we do not have analytical information on each brand, and thus we can only calculate the nutrient content of brands based on ingredients given on the food label. A satisfactory food composition database must have good values on basic foods, especially local agricultural products, because we need that information all the time. The database should include representative foods that are eaten by a significant portion of the population and have a noticeable impact on nutrient intake.

Vitamin losses

Most analysed values for nutrients or other dietary components have been obtained for basic raw food stuffs in the Finnish Food Composition Database. By contrast, McCance and Widdowson's publication *The Composition of Foods* includes analysed values for the vitamin C content for potatoes boiled without skins or with skins, French fries or boiled broccoli, as well as for many fruit pies (Holland *et al.*, 1991). For some other dishes such as mashed potatoes, puddings or cakes, the recipes were used for calculation of nutrient composition. Losses of vitamin C have been assigned for each individual recipe and range of losses was found to vary from 10 to 70%. A principle mentioned by Buzzard & Feskanich (1987) is the following: 'Include foods only in the forms in which they are eaten.' There is a serious gap concerning nutrient composition of 'foods as consumed' in Finland.

The sophisticated recipe calculation procedure includes several steps (Perloff, 1986; Beecher & Matthews, 1990; Bergström, 1994) where weight and nutrient changes can be controlled. The retention factors used for vitamin losses during cooking have only partly been applied in Finnish dietary studies. Nowadays when comparisons between European countries are becoming more frequent, it is obvious that Finnish studies, too, need such corrective factors. A group of the Eurofoods Enfant Project collected data related to nutrient losses during food preparation. The aim of the project was to recommend factors for the evaluation of losses in nutrient intake calculations (Bergström, 1994). The final document includes information from several European countries and the United States. Unfortunately, no recommendations for common retention factors were given.

In a recent dietary survey of Finnish adults the intake of vitamin C was calculated to be 135 mg/day for men and 147 mg/day for women (Kleemola *et al.*, 1994). Over 60% of this amount was derived from fruits and berries, consumed as such or consumed in desserts such as jellies, sweetened soups or pies. A third was derived from vegetables including potatoes. However, the total intake was calculated based on raw food items except for boiled potatoes and some other boiled vegetables. In further analyses Eurofoods factors for nutrient losses were applied. Descriptions of food source and cooking methods were taken into account in the re-estimation on vitamin C intake. The additional decrease in vitamin C intake was about 15%. The decrease was rather slight, because the intake of vitamin C was mostly based on consumption of fresh fruits, berries and vegetables (70% of the intake was derived from uncooked products). The highest decrease was seen in proportional intake derived from cooked dishes containing vegetables.

CHALLENGES

Because of the importance of the recipes in the Finnish Food Composition Database the standardization of recipe calculation is the most important point for the future. Application of retention factors for other nutrients, besides vitamin C, is also actual. Priorities for further analyses of nutrient composition in general and in cooked dishes should be concluded. The importance of analysing local basic foods and foods 'as consumed' is emphasized. Finally the need for variance information on the nutrient content in local foods is recognized.

For data exchange the identification of foods and nutrient factors must follow current guidelines. For cooperation the description of foods needs a systematic approach (Truswell *et al.*, 1991). Nowadays in Europe collaboration between states and national institutes is actively increasing and is encouraged. In Europe several multinational studies are presently under way: for example, the European project on calcium intake and bone density (CALEUR) and the study of trans fatty acid intake and risk factors for cardiovascular disease in Europe (TRANSFAIR). The comparability and accuracy of the results in dietary surveys can be improved by following international guidelines in the compilation of food composition databases (Klensin *et al.*, 1989; Greenfield & Southgate, 1992).

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