PROCEEDINGS OF THE NUTRITION SOCIETY
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Symposium on 'Nutritional assessment and surveillance: implications for food policy 2. Are we measuring what we intend to measure?'

Different techniques of food preparation and cooking: implication for dietary surveys

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In 1950 the 'Man from Tollund' was found in the Tollunds mosse, a peat-bog near Silkeborg in Denmark. This man had obviously been executed. A botanist, Dr Hans Helbaeck, examined the food residues in the grave and found that the man had eaten a porridge which contained a mixture of plant remnants. There were both cultivated and wild seeds, from barley (*Hordeum vulgare*), flax (*Linum usitatissimum*), knotweed (*Polygonum*), green bristle grass (*Setaria viridis*), purple butterbur (*Petasites officinalis*), dull-seed cornbind (*Polygonum convolvulus*) and lamb's quarters goosefoot (*Chenopodium album*), among others. In another grave-find, Dr Helbaeck found sixty-six different seeds in the porridge. This kind of porridge was probably used as everyday food, at least in winter time, during the Earlier Iron Age around the Birth of Christ. Other finds show that the human diet at that time also contained meat, fish, fruit and berries and perhaps milk and cheese.

Of course, corresponding porridge had to be cooked and tasted, which was done on British television in 1954 in the presence of two invited archaeologists, Sir Mortimer Wheeler, London University, and Dr Glyn Daniel, Cambridge University. Sir Mortimer was reported to have said that even if the Tollund man had been a hardened criminal, it ought to have been sufficient punishment to have to eat a bowl of this porridge. The two tasters were delighted to be able to wash down the food with excellent Danish schnapps.

The first comprehensive description of a bog find, a woman in a bog near the mountain Drukeragh in Down, Ireland, in 1780, was written by Lady Moira (Glob, 1965).

DIETARY SURVEYS

Nowadays, in order to get information on food consumption and nutrition intake in different groups we do not have to examine grave-finds and garbage piles. Instead we are conducting dietary surveys using nutritionists, dietitians, nurses, physicians, computer systems analysts, technicians and assistants, chemists and compilers; questionnaires, measuring utensils, food pictures, food scales; food composition database systems, etc.

The modern diet of different groups is well documented both in dietary studies and in nationwide surveys, for example, in Great Britain, in 1995 with the *National Diet and Nutrition Survey: children aged $1^1/_2$ to $4^1/_2$ years* (Gregory *et al.* 1995) and in Sweden, *Food Habits and Nutrient Intake in Sweden, 1989* (Becker, 1994). In order to estimate the nutrient content of a diet, reliable food composition databases are essential.

COOPERATION ON FOOD COMPOSITION DATABASES

In the 1970s people working on or using food composition databases started to cooperate more actively than before, both internationally and nationally. This cooperation began in Europe in 1972 at a conference in Zürich with a working party of the Group of European Nutritionists and in the US in 1976 with the 1st National Nutrient Databank Conference. In 1982, both INFOODS, Eurofoods and Norfoods (for definition, see Appendix) started their activities. Eurofoods and Enfant (see Appendix) continued the cooperative work within FLAIR (Castenmiller & West, 1994; Appendix). In 1993, the First International Food Data Base Conference took place in Australia and the second, in 1995, was in Finland. In Europe, the cooperative activities are now continuing within COST 99 and within EuroNIMS (see Appendix). This cooperation has consequently resulted in numerous books and reports. The participants have also been working on two coding systems for foods, Eurocode and Langual ((US) Food and Drug Administration, 1992; Appendix).

NUTRIENT LOSSES AND GAINS PROJECT

At a meeting of the Eurofoods group in Wageningen in 1983, the Nutrient Losses and Gains Project (NLG Project) was established. The aim of the project was to collect data related to nutrient losses and gains in the preparation of foods with a view to recommend factors for use in the calculation of the nutrient content of foods and recipes. Two main types of factors are needed: (1) yield, weight yield or weight change factors; (2) NLG, nutrient yield or nutrient retention factors. Weight change is the yield value (%) minus 100.

The NLG project work resulted in three reports: (1) Nutrient losses and gains in the preparation of foods; (2) Nutrient losses and gains references; (3) Yields for foods and dishes in Europe; these have been combined in one document (Bergström, 1994). The reference and yield tables are also available on a diskette.

At the National Food Administration in Sweden, a pilot study to build a model for an NLG database was also conducted. The model was reported and demonstrated at the Eurofoods Norwich meeting in 1985. The National Food Administration could not at that time obtain funds to create a NLG database.

NUTRIENT LOSSES AND GAINS FACTORS

Factors for vitamin and mineral changes in foods during preparation of foods or dishes are used in several countries in the computer processing of recipes. Usually the factors are for vitamins, but in a few countries factors for minerals also exist, such as in Germany, Denmark and the US. The factors can be applied at different levels of accuracy. The main levels are for (1) recipe, (2) food group, (3) food item. The borderlines between the main levels should not be considered fixed and within each main level NLG factors can be applied at different sublevels.

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In 1990, work on NLG standard factors at the recipe level was undertaken at the Swedish National Food Administration. Factors were applied to eleven vitamins (retinol, β-carotene, ascorbic acid, thiamin, riboflavin, niacin, vitamin B_6, folate, vitamin B_{12}, pantothenic acid, biotin). Separate factors were determined for preparation without heat and the cooking methods of boiling, shallow frying and baking or roasting. These were used for all food groups, except meat and poultry, for which alternative factors were derived. The NLG factors were based on mean values (some values are modified) of factors published by different government agencies.

A test was performed with these NLG factors where nutrients from directly analysed dishes were compared with nutrients from differently calculated recipes. Good agreement was achieved in some cases but not in others. The observed differences may have been due to differences between nutrient contents of the analysed ingredients and the ingredients included in the database.

This comparison was simply an example of a small practical experiment. Many chemists consider that comparisons like these must always be performed on a dry matter basis. But on the other hand, a practical method of calculating recipes on the basis of wet weight with standard NLG factors is needed.

At the National Food Administration, research has been performed on standard dishes, raw and cooked, in order to study the nutrient losses and gains in cooking foods. The results will be published shortly (I. Torhelm).

Even though the FLAIR Eurofoods–Enfant Project officially ended in March 1994, the wish to continue cooperation and work on NLG factors in Europe remained.

FACTORS AFFECTING WEIGHT AND NUTRIENTS IN FOOD

In the cooking of foods, the weight and nutrient changes in the foods mainly depend on conditions affecting the water content, but there are also other factors. Some of these factors are: cooking method; cooking utensils, such as size and volume of cooking vessel; lid or foil covering food during cooking; cooking time; cooking temperature; final internal temperature, e.g. in cooked meat; food quality; the part of animal or plant used; physical state, shape or form of foods; surface:volume; food tissue type and texture of food surface; amount of food cooked; amount of liquid added; temperature of liquid added; amount of fat added; type of fat added; food cooked with or without bones; time passed between the termination of cooking and measuring the yield.

For nutrient changes in vitamins and minerals, the following factors, in addition to leaching of nutrients into cooking liquid or drippings from foods in frying, are of special importance: temperature; time; catalysts such as Fe and Cu in the metal of cooking utensils, such as knives, saucepans, frying pans, etc.; water (water activity and content in the foods or added water); pH; O_2; light; enzymes; sulphite; Cl; inhibitors; interactions.

Considering all the previously mentioned conditions it is understandable that there are many variables in a NLG database. Furthermore, the main part of this information will be missing in a recipe calculation system.

RECIPE CALCULATION

Recipes are usually included in the various food composition tables and databases all over the world. The national and the most-frequently consumed dishes in a country should preferably be analysed for nutrients. As analyses of foods are expensive and time-consuming, especially considering the great variety of recipes, the calculation of nutrient content from recipes has become a necessity, even if the results are estimates.

During cooking the weight change consists mainly of the loss or gain of water. Change in water content in foods and dishes is the main factor affecting every nutrient. Loss in water will increase the concentration of nutrients, and gain of water will decrease their concentrations. In dishes cooked with different frying methods, the frying fat has also to be taken into account. For these dishes it was considered necessary, since the first edition of the British food composition tables (McCance & Widdowson, 1940), to analyse the water and fat contents in the cooked dishes before being able to calculate the concentrations of other nutrients in the dishes.

The recipes in various recipe calculation systems are usually written in a standardized way. To accomplish this, the following standardized components are needed for a food composition database system: nutrient database; calculation programmes; component values; code replacements; conversion factors, e.g. for fatty acids; recipes; recipe file; household measure; helpings or servings information; yield or weight yield factors; NLG (i.e. nutrient yield or nutrient retention factors); research methods; documentation.

In dietary studies, it is usually convenient to have a standardized recipe file containing recipes of dishes chosen for their representativeness in a country. In order to save time, the nutrient content for recipes can be precalculated and included in the standardized recipe file.

RECIPE CALCULATION SYSTEMS

Several European developers of recipe calculation systems are using the British method described in *McCance and Widdowson's The Composition of Foods*, the fourth (Paul & Southgate, 1978) or fifth edition (Holland *et al.* 1991), but there are other systems available; for example, in Europe, a system has been developed at the Federal Research Centre for Nutrition in Stuttgart, Germany, and within EuroNIMS several European national partners are involved in developing a common system, including recipe processing system. In the US, there are several recipe calculation systems.

PREPARATION AND COOKING METHODS IN FOOD COMPOSITION DATABASES

In addition to Langual's ((US) Food and Drug Administration, 1992; Appendix) preparation and cooking methods, there are other organizations working on standardizing the meaning of different preparation and cooking methods.

A working party within COST 91 developed a list of cooking terms, with a definition of each term included. These terms are intended to be used for the planning of experiments and the presentation of experimental data in industrial cooking and catering. The terms are given, as a first step beyond English, in the following languages: Danish, Dutch, Finnish, French, German, Greek, Italian, Serbo-Croatian, Spanish and Swedish. The terms are later also given in Czech, Icelandic, Norwegian, Hungarian, Portuguese and Turkish. The publication of the lists is planned for 1996.

The Swedish Test Kitchens have recently identified and defined about 400 Swedish preparation and cooking terms; the terms are also translated into English (KF, ICA & Jordbrukets Provkök, 1995).

National databases, except those coded in Langual, include rather few preparation and cooking terms and the ones included are not always fully defined. For example, general terms such as smoked or dried are used. At which temperature is the food smoked and how is the food dried? A trained person might be able to see from the water content which method is used.

ARE WE MEASURING WHAT WE INTEND TO MEASURE?

There are four main areas where shortcomings may occur in dietary surveys: methodology, standards, food composition database, and recipe calculation.

Methodology

According to the method used there might be over- or underestimation of the food intake in dietary surveys. It is also very easy to omit food eaten.

Standards

Even if standardized recipes, food servings and food weights are convenient to use in a survey, individuals probably do not eat standard servings.

Food composition database

If a food is missing in the database and is replaced with a similar food, or if a preparation or cooking method of a food is not correctly defined, you cannot get the food's correct nutrient value. Furthermore, it must be remembered that we know very little about the nutrient content of the food which we are actually eating. Information on, for example, growing conditions and storage time for fresh vegetables, is missing. Furthermore, even if a food is analysed, the nutrient values derived apply only to the food items analysed.

The chemical analytical methods used on foods are continuously controlled and improved; however, the calculation methods for recipes in the different calculation systems might be a weak point.

Recipe calculation

Some examples of weaknesses that may occur in recipe calculation systems are:
(a) as stated by a Swedish food technologist, 'Cooking is the art of moving water' and if you master this art, the weight change for a dish should not vary too much and the sensitive nutrients in a dish will be protected (Dahlgren, 1994). Nonetheless, the yields for recipes and retention of the vitamins vary exceedingly, which probably reveals, for example, the cooking habits in a country.

Two dishes, fried meatballs and vegetable soup are compared in Table 1. Consistent results were obtained, and show that as water content in a dish decreases, the concentration of nutrients rises.

(b) a more complicated relationship is the one between food and fat, usually frying fat. Fat may be lost, gained, or remain unchanged. Whole meat (uncoated cuts of meat), with a fat

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Table 1. *Two dishes, fried meatballs and vegetable soup, that were directly analysed (A) and computer-processed are compared*

(Nutrient content is shown assuming no weight change (i.e. uncooked ingredients), and after applying two different weight-yield factors. The same recipe and the same database were used throughout. The nutrient-retention ranges for thiamin and ascorbic acid in fried meat and boiled vegetables from six different countries are given)

	Factor applied	Water (g)	Protein (g)	Fat (g)	Thiamin (mg)	Ascorbic acid (mg)
Meatballs, fried	A	66	15·1	10	0·17	1
Uncooked ingredients	1	73·2	11	9·3	0·15	1·12
Weight-yield factor:	0·91	70·6	12·1	10·2	0·17	1·24
	0·8	67·7	13·3	11·2	0·18	1·36
Retention range (%)					45–95	
Vegetable soup	A	93	0·9	0·2	0·02	1
Uncooked ingredients	1	93·9	1·3	0·2	0·02	4·4
Weight-yield factor:	0·93	93·4	1·4	0·22	0·02	4·73
	0·88	93	1·5	0·24	0·02	5
Retention range (%)					45–95	20–95

content of 2–40%, loses about 15% fat in boiling, shallow frying and roasting, except bacon which has a 60–70% loss. Whole meat does not take up any, or minimal, amounts of the frying fat. For ground beef, the melting loss is higher in the fatter types and is also higher than that for ground pork. A very small amount of fat is taken up in frying ground meat, sausage and black pudding, 1–2 g/100 g unfried food (Laser Reuterswärd & Johansson, 1987, 1990; Johansson & Laser Reuterswärd, 1987).

In experiments performed by Van den Bergh Foods in Sweden (Fredholm, 1991; Fredholm *et al.* 1991), it was found that 100 g raw food absorbs fat as follows: meat or fish with thin coating (dipped in, for example, milk then turned in sifted flour and/or finely-ground dried breadcrumbs) 3–4 g, with coarse coating (dipped in, for example, milk, turned in sifted flour, dipped in egg and finally turned in dried breadcrumbs) 7–9 g, and potatoes 6–8 g fat in frying. Studies on deep-frying of foods have been performed, for example, in Australia by Makinson *et al.* (1987) and in Spain by Varela & Ruiz-Roso (1992), and Pan *et al.* (1993) have reported the cooking-oil absorption by food during Chinese stir-frying.

At least among Swedish food technologists, the task of creating fat factors to be used in recipe calculation is still considered rather complicated. Regarding different meat cuts, one difficulty is that the weight change (water loss) may vary depending on, for example, cooking method, meat quality, final internal temperature (which in turn depends on cooking time), while the fat loss is independent of, for example, the final internal temperature and is, in this case, constant for a meat cut.

In recipe processing, should the frying fat be included in or omitted from the recipe? Both ways have their advantages and disadvantages: if included the amount of fat is standardized; if omitted, it may be forgotten and not recorded;

(c) when making recipes, some ingredients will be left over, for example when food is breaded, floured or batter-coated before frying. Standard factors for breading, flouring and batter-coating are required, as cook-book recipes usually give more milk, flour, eggs, dried breadcrumbs, salt, batter etc., than are needed. Only by experiments can such factors be created;

(d) the food left on the plate, fat trimmed off, dressing, sauce etc., is rather difficult to estimate. There is still much work to be done on recipe calculations.

YEAR 4000

What will happen within the next 100 years? Will mankind still exist? What will people eat? Will the food be some kind of extruded crackers, rationed to each person with the exact amount of nutrients that the person in question will need. If the food is analysed in advance, there will be no more dietary surveys. What a dull world for a nutritionist! And in 4000, what will there be left for the archaeologists to study regarding foods? Nothing?

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APPENDIX: TERMINOLOGY

Cooking	The method by which a food is precooked, cooked, reheated or held warm (Langual, short definition)
COST	European Cooperation in Scientific and Technical Research
Dish	A single food or a mixture of foods prepared according to a recipe
Enfant	European Network on Food and Nutrition Tables
Eurocode	A coding system for foods created to be used, for example, in dietary surveys
Eurofoods	A group of people working towards improvement and dissemination of food composition data in Europe. This group continued its work within the FLAIR Eurofoods–Enfant Project
EuroNIMS	A food information management system, developed in Belgium for several European national partners
FLAIR	Food-Linked Agro-Industrial Research
FLAIR Eurofoods–Enfant Project	A project, funded by the Commission of the European Union, and entitled: Improvement of the quality and compatibility of food consumption and food composition data in Europe. The project started in October 1990 and ended in March 1994
Food	Commodity, raw food, product, dish, prepared food, intended for human consumption
INFOODS	International Food Data Systems
Ingredient	A food included in a recipe
Langual	Langue des aliments or language of food is an automated method for describing, capturing and retrieving data about food. It has been developed by the Center for Food Safety and Applied Nutrition (CFSAN) of the US Food and Drug Adminstration (FDA). Since 1975 it has been an ongoing cooperative effort of specialists in food technology, information science and nutrition. Langual is based on the concept that: Any food can be systematically described by a combination of descriptors or factors (fifteen types) These factors are divided into four main groups: food origin; processing operations; packing and packaging and other information and coded for computer processing The resulting combined factor codes can be used to retrieve data about the food
NLG	Nutrient losses and gains (in the preparation of foods)
Norfoods	A group of people in the Nordic countries working on coordination of the Nordic food composition databases and tables
Nutrient yield or nutrient retention	A term used for what is retained of nutrients, especially vitamins and minerals, in a food or dish after, for example, storage, preparation, processing, warm-holding or reheating. Nutrient yield or retention is usually expressed as a percentage of the nutrient content of the food before storage or different treatments
Nutrient yield factor or nutrient retention factor	A nutrient yield or retention used as factor, e.g. in calculation of recipes
Preparation method or processing method	Used to describe the method of preparation and/or processing, which is primarily cooking in this context. In the NLG report title, preparation covers both preparation and/or processing and cooking
Product	Food commercialized under a specific brand name by a manufacturer
Weight change	A term used for loss or gain of weight in a food or dish after, for example, storage, preparation, processing, warm-holding or reheating. Weight change is the yield value (expressed in %) minus 100
Weight-change factor	A weight change used as factor, e.g. in nutrient calculation of recipes
Yield or weight yield	A term used for what is obtained of a food or dish after, for example, storage, preparation, processing, warm-holding or reheating. Yield is usually expressed in %
Yield factor or weight-yield factor	A yield or weight yield used as factor, e.g. in nutrient calculation of recipes

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