Characteristics of the South African Food Composition Database, an essential tool for the nutrition fraternity in the country: Part I

Wolmarans P, Danster NA
Nutritional Intervention Research Unit, Medical Research Council
Correspondence to: Dr Petro Wolmarans, e-mail: petro.wolmarans@mrc.ac.za
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Abstract

Information on the nutrient composition of food forms the foundation for determining the diet-health-disease-relationships in a country. The nutrient composition of foods is influenced by many factors such as climate, soil, cultivar/breed, the grade of ripeness at harvest and the storage of food. Therefore, it is especially important to have a country-specific food composition database that caters for the dietary habits of all the country's people. Different methodologies are used for generating information on the nutrient composition of foods, e.g. chemical analyses, calculations, imputations, information from other food composition databases and the scientific literature. Knowledge of the characteristics and limitations of food composition data is a prerequisite for the responsible use and application of the information on the nutrient composition of foods. A food composition database is an essential tool used by the nutrition fraternity in an effort to improve the dietary habits, and thus the health, of the population.

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Introduction

The energy and nutrient content of a food item provides information on its nutritional characteristics, and this information has through the years been captured in food composition databases around the world. Information on the energy and nutrient composition of foods is a prerequisite for analysing dietary intake data and aids in establishing the diet/disease relationship in a community or country. In addition, information on the nutrient composition of food is also essential for achieving dietary intake goals.[1]

In 1981 the first edition of the Medical Research Council (MRC) Food Composition Tables (FCT) was printed to provide research professionals with a tool that could be used in the analysis of dietary intake data collected as part of large epidemiological studies.[2] Two updates of the FCT later became available, in 1986 and 1991 respectively.[3,4] Two supplements on the fatty acid and amino acid composition of foods were also published, in 1987 and 1992 respectively.[5,6] In 1995, investigators from the Nutritional Intervention Research Unit (NIRU) of the MRC, who were responsible for the compilation of the MRC Food Composition Tables, initiated the formation of the South African Food Composition Data (SAFCoD) committee. The aim of this committee was to join forces with other role players in the field of food composition to generate more nutrient data on South African foods and to make the process more inclusive. Representatives of several interest groups in nutrition became involved in SAFCoD, including the Department of Health and the Department of Agriculture; research councils such as the MRC, the Agricultural Research Council and Foodtek of the Council for Scientific and Industrial Research; user groups such as the Association of Dietetics in South Africa, the Nutrition Society of South Africa, the South African Association for Food Science and Technology, the Consumer Goods Council of South Africa; as well as the South African Bureau of Standards, one of the major analytical laboratories in the country. An electronic food compilation database management system, called the South African Food Data System (SAFOODS), was subsequently developed by NIRU researchers to record and manage the information generated for the South African Food Composition Database. As a result of the efforts of the SAFCoD steering committee and with the aid of financial support from the Department of Health and the Meat Industry, information on the nutrient composition of South African vegetables, fruit and beef was generated for inclusion in SAFOODS. Two supplements to the 1991 Food Composition Tables were produced that included this newly generated information.[4,7,8] Today, these tables are regarded as the main sources of information on the nutrient composition of foods consumed in South Africa. A new edition of the FCT, "Condensed Food Composition Tables for South Africa", which will include data from the 1991 Food Composition Tables as well as the updated information from the two supplements, will become available at the end of 2008.

In addition to the Food Composition Tables, a Food Quantities Manual (FQM) was published in 1986 and updated in 1991.[9,10] An updated version of the FQM is envisaged for 2009. The FQM provides information on the weights of foods, measured with household utensils, e.g. cups and spoons. This information is available for the food items in the South African Food Composition Database. Weights for different dimensions of food are also available in the manual, e.g. an apple with a diameter of 70 mm or a slice of bread 93 x 93 x 10 mm. Special dishes and cooked foods were prepared by the authors of the FQM before being measured according to standardised procedures.[9,10] The weights of these various dishes were then included in the FQM. Dietary intake data is normally collected in household measures, but has to be translated into grams of food for computer analysis. The FQM therefore forms an integral part of the tools needed by nutrition professionals when they plan to translate dietary intake data reported in household measures into a format which can be used for nutrient analysis.

Dietary analysis software programs, which are based on the nutrient information of food items in SAFOODS, have also been developed by NIRU since 1992 in collaboration with private software developers. FoodFinder[3] was specifically developed with the aim of meeting the needs of those interested in nutrition-related research.[11] This program allows researchers to analyse the diet of an individual or groups of individuals. Nutrient information on new food items can be added to the program, as well as recipes for special dishes. An export function that allows users to export the data to Excel is included in the program. FoodFundi, another dietary analysis software program, which is based on the nutrient information in SAFOODS, has many of the functionalities available in FoodFinder[3]. FoodFundi, however, also contains functionalities specifically aimed at the dietician in private practice who is involved in the dietary treatment of individual clients.[12]

The International Network of Food Data Systems

The International Network of Food Data Systems (INFOODS) was established in 1984.[13] The aim of INFOODS is to improve the quality of food composition data internationally, in order to make the data more accessible and compatible for all interest groups.[13,14] The activities of INFOODS are managed under the auspices of the Food and Agricultural Organization (FAO) of the United Nations and the United Nations University, and are coordinated from the offices of the FAO in Rome, Italy.[13] The information on 11 regional data centres can be accessed through the INFOODS website (http://www.fao.org/infoods/index_en.stm). An African Network of Food Data Systems (AFROFOODS), established in Ghana in 1994, is one of these regional data centres.[15] AFROFOODS consists of six sub-regions. The Southern Africa Food Data System (SOAFOODS) is one of the six sub-regions of AFROFOODS and South Africa belongs to this sub-region. The other countries that belong to SOAFOODS are Zimbabwe, Botswana, Lesotho, Swaziland, Zambia, Namibia, Malawi, Mauritius and Djibouti.

Do we need a Food Composition Database for South Africa?

The question is often asked why we need a food composition database for South Africa if other extensive information is available, e.g. the food composition database of the United States Department of Agriculture (USDA) and the British food composition tables. There are several reasons why a country-specific food composition database is necessary, especially in view of the major and growing developments in the science of nutrition/dietetics.

Dietary habits

Dietary habits of populations differ not only in the type of food eaten, but also in the use of special recipes and preparation methods that impact on the nutrient composition of foods. Differences in the dietary habits of South Africans, for instance, vary from a simple diet in which maize meal products or bread are the staple food, while other segments of the population follow a diet consisting of a variety of foods.[16,17] A more traditional diet with maize meal products as the staple food is followed especially by those living in the rural areas of the country.[17] Additionally, the use of indigenous foods, e.g. mopani worms, as well as special recipes, e.g. samp and beans, eaten by some of those following the more traditional diet, has to be catered for in the national food composition database. Information on the nutrient content of such foods and special recipes would not normally be available in international databases, and it is therefore necessary to analyse these foods chemically or to calculate the recipes for inclusion of the information in the country-specific food composition databases. Furthermore, eating away from home has become a very common practice, and therefore fast foods form a large part of the diet, which in turn creates a need to incorporate nutrient information on fast foods in country-specific databases.

Environmental factors

Climate and temperature are known factors that influence the nutrient composition of food.[18] South Africa is a vast country with a total land area of slightly more than 1.2 million square kilometres. It measures about 1 600 km from north to south and approximately the same from east to west.[19] The country has different climatic regions, varying from a winter rainfall area in the south and summer rainfall in the rest of South Africa. The expanse of the country creates challenges for food composition database compilers when provision has to be made for the collection of representative samples of agricultural products such as wheat, for example. Wheat is produced in both the winter rainfall area in the Western Cape as well as in the summer rainfall area in the north of the country, and this could impact on the nutrient composition of the wheat. Differences in soil types also influence the nutrient composition of foods, e.g. vitamin and mineral content, and especially that of the trace elements.[13]

Fortification

In South Africa, maize meal products and bread are the two main staple foods.[16] Since 2003, maize meal and white bread flour have been fortified in accordance with legislative requirements to address specific micronutrient deficiencies in the country. The nutrients used in the fortification of food and the level of fortification may differ from country to country. It is therefore important to generate information on the nutrient composition of fortified staple foods eaten in South Africa for inclusion in SAFOODS. Two NIRU studies generated country-specific nutrient information on maize meal and maize meal products, white bread flour and white and brown bread.[20,21]

Other factors

The nutrient composition of different cultivars of a food can differ and the storage of the food(s), as well as the grade of ripeness at harvest, may also influence the nutrient composition of foods.[13,18] These selected examples of factors that may influence food composition serve to underscore the importance of having a country-specific food composition database.

Selection of food for inclusion in South African Food Data System (SAFOODS)

Thousands of food items are available on the market in South Africa. From a practical point of view, it is simply not possible for the compilers of food composition databases to include all these food items in a food composition database. A strategy, therefore, has to be followed to ensure that all the foods most frequently eaten by South Africans are included in the country-specific food composition database. The model proposed by Greenfield and Southgate[13] is of special importance and can be used as a guideline on how to approach the process of deciding which food items should be included or excluded from a country-specific food composition database. This model has been adapted to give an indication of how it is used within the South African context (Figure 1). Dietary information collected by means of national surveys, such as the South African National Food Consumption Survey (NFCS),[22] as well other published dietary data, provide information on the types, amounts and frequencies of foods consumed by a large percentage of the population. In addition, the foods that contribute the most to specific nutrients of interest can also be identified. For instance, an inadequate intake of vitamin A, iron and zinc has been documented by the NFCS, and it therefore is necessary to ensure that the most important sources of these food items are included in the database. Since no one study alone can provide all the necessary information on the range and type of commonly consumed foods, it is imperative that all available information in the literature on the consumption of food(s) is used in the selection of foods for inclusion in the country-specific database.[23]

Another important factor that influences the decision on which foods to include in a country-specific food composition database is the nutrition-related disease patterns present in a given country. In South Africa, for instance, the burden of disease due to obesity and that due to micronutrient deficiencies co-exist.[24–26] Foods that play a role in chronic diseases of lifestyle, e.g. high-energy, high-fat and high-cholesterol foods, have to be included in the food composition database so as to enable researchers and health professionals to assess the diets of those who are at risk and to subsequently introduce healthy alternatives. By necessity, therefore, the food composition database must make provision for the inclusion of low-energy and low-fat alternatives in order to enable health professionals to adapt the diets of those individuals or groups of individuals who require such diets.

Retail statistics, e.g. the main types of margarine purchased by South Africans, serve as a guideline to identifying the margarines for which nutrient information should be included in SAFOODS. Food trade between countries should also be considered when selecting foods for inclusion in the database.[13] Information on food trade and statistics, e.g. the import of wheat into the country, serves as a useful guideline regarding decisions that should be taken on the inclusion of the nutrient composition of a specific food commodity.

Specific research interests in a country also influence the types of food(s) included in a food composition database. As an example, there may be a special focus on fatty acid research and the database compilers therefore need to ensure that the database makes provision for the main food sources of the different fatty acids, e.g. omega-3, omega-6 and omega-9 fatty acids. In other instances, researchers may also have an interest in iron status research, and such cases require information on the total iron content of a food item as well as on the haeme and non-haeme iron content of a food. Additionally, major food sources fortified with iron also have to be included in such a specialist food composition database. Nevertheless, and in real terms, compilers of food composition data have to make decisions regarding whether it is in the interests of the whole country to spend time and resources on adding this additional information to a database. In South Africa, we have not yet had the luxury of nationally compiled specialist databases for specific nutrients. However, those interested in research on specific nutrients not extensively covered by the national database, e.g. carotenoids, phytates and caffeine, are encouraged to compile their own food composition database addressing the nutrients of interest to them. Such data could be linked, in collaboration with the compilers of SAFOODS, to the national food composition database for use by others.

Determination of the nutrient content of foods presented in a food composition database

Having a complete food composition database that contains information on all the important foods and their nutrients would be the ideal situation, but this is virtually impossible.[13,27] Even databases that are incomplete can be considered to be of good quality and can be used, provided they meet specific criteria. A database can be regarded as complete by making use of different methodologies, e.g. analysed, borrowed or best-guess values, to produce data on all the core foods and their components.[27] One of the most important aspects, however, is to record the methodology used for the determination of the specific nutrients in the compilation database. It is essential to indicate whether calculations, imputations, assumptions, etc were used to generate a value for a specific nutrient. Another approach is to compile a database in which only data generated by chemical analysis is recorded. It has to be

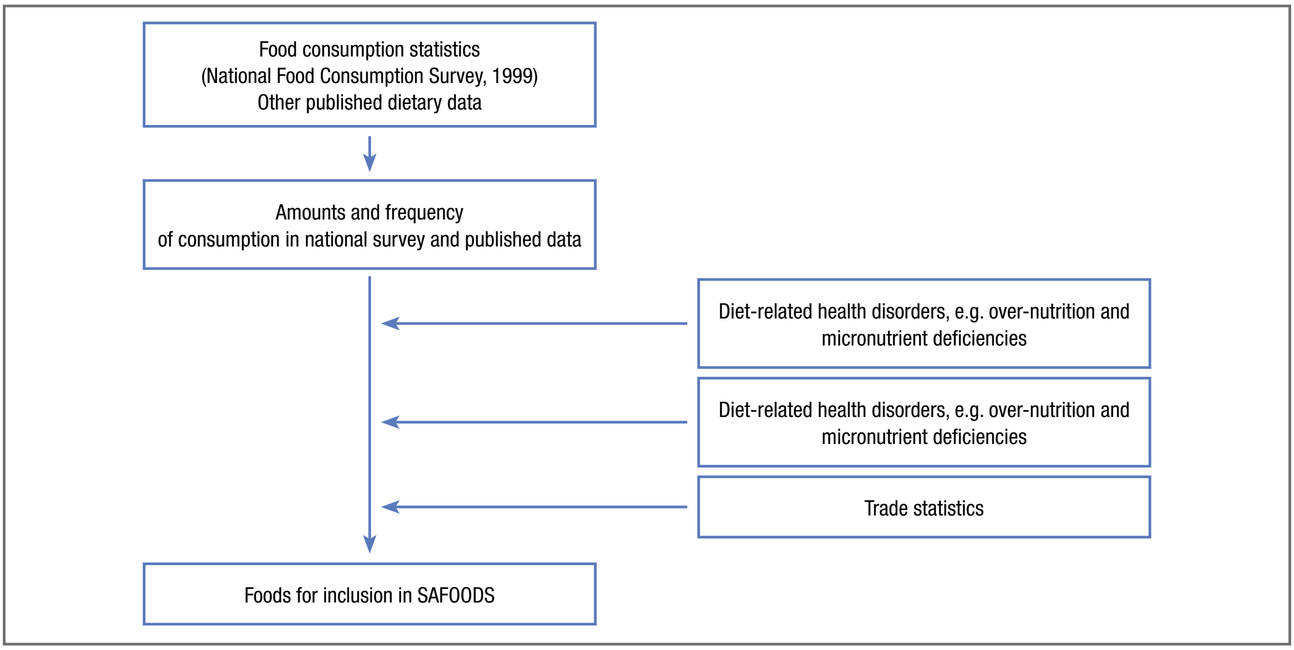

Figure 1: Model used as a basis for selecting food(s) for inclusion in the South African Food Composition Data System (SAFOODS)[13]

accepted that, in the latter type of database, there could be many foods and nutrients that will be missing if the database is based only on the chemical analysis of foods.[27] It should be borne in mind that, contrary to what is often assumed, the information on the nutrient content of food items in a food composition database is not always based on chemical analysis. This is also true for the South African Food Composition Database, which uses various strategies for the generation of data on the nutrient composition of foods. These include chemical analyses, calculations, recipe calculations, estimating the information from similar foods and using information from other food composition databases, as well as information in the literature.

Chemical analysis

Although the chemical analysis of foods is the "golden" standard, it is not always possible to analyse foods chemically, as it is an extremely expensive undertaking and budget constraints do not allow for the costly analysis of all the foods and their nutrients for inclusion in the database. In addition, the methodology used for the analysis of the nutrient composition of foods needs to be accurate and repeatable, and should be conducted by trained analysts in well-equipped laboratories. One of the most important aspects when food is analysed chemically is to ensure that the correct sampling procedures are used.[13] Factors such as the representativeness of the sample, seasonality, state of ripeness at harvest, geographical area, cultivars and breed have to be considered when sampling food for chemical analysis.[13] It should also be borne in mind that, due to budget constraints, it often is not possible to chemically analyse several samples of the same food for the purpose of determining the mean value as well as the standard deviation. More often, therefore, it is representative samples of the selected food that are combined to form a composite sample before it is analysed.

The importance of using the appropriate methodology for the chemical analysis of the nutrient composition of foods can be illustrated by the results reported on the analysis of two different types of margarine for fatty acid content, especially trans fatty acids (Table I). When a 30 m column (normally used for routine analysis) was used on the gas liquid chromatograph (GLC), no trans fatty acids were detected in margarines A or B. Consequently, the former (margarine A) appeared to have a higher mono-unsaturated fatty acid (MFA) content and might have been considered to be a better choice than the latter (margarine B).[28] However, using a 120 m column, which made the detection of trans fatty acids in margarine A possible, showed that a large percentage of the MFA in margarine A actually consisted of trans fatty acids. Clearly, therefore, the use of inappropriate methodology for the determination of nutrients in food may have serious implications for researchers as well as health professionals, since wrong conclusions may be drawn from the nutrient information presented in a database.

Table I: Fatty acid composition of two types of margarine (A and B) using gas liquid chromatograph columns (GLCs) of different lengths[28]

Fatty acids	30 m GLC column		120 m GLC column	
	Margarine		Margarine	
	A (%)	B (%)	A (%)	B (%)
Saturated	27.6	34.7	27.6	34.7
Mono-unsaturated	49.8	34.7	31.3	34.7
trans-mono-unsaturated	-	-	18.5	0.0
Polyunsaturated	22.6	30.6	22.6	30.6
Total fatty acids	100	100	100	100

Calculations

Calculations can also be used to determine the nutrient content of a specific food item in the food composition database. For example, this can be done if information is available only on the total fat content of a specific food item. Appropriate conversion factors can then be used for the calculation of the saturated fatty acid (SFA), mono-unsaturated fatty acid (MFA) and polyunsaturated fatty acid (PUFA) content of this food.[29] The conversion factor for lean beef is 0.916. In order to calculate which part of total fat constitutes fatty acids, the total fat content of lean beef has to be multiplied by the appropriate conversion factor, i.e. 0.916. As an example, if the total fat content of lean beef is 7.5 g, then the total amount of fatty acids (SFA + MFA + PUFA) is 0.916 x 7.5 g = 6.87 g. The rest could be non-fatty acid components such as glycerol, sterols and the phosphate moiety of phospholipids. This also explains why summing the SFA, MFA and PUFA values of a specific food item does not add up to 100% of the total fat content of the food. Further calculations can then be applied to determine the amounts of SFA, MFA and PUFA respectively that are present in the total fatty acids of lean beef. In general, therefore, calculations are only an estimate of the real value, but for research purposes are still preferable to missing values in the database.[30]

Recipe calculations are also often used for the calculation of the nutrient content of combined dishes, especially traditional dishes such as samp and beans, bobotie, biryani and roti.[10] When calculating the nutrient content of recipes that include raw foods as ingredients, provision has to be made for adapting for the moisture content of these foods and to compensate for the nutrient losses due to preparation.[7] The vitamin content of a food is known to be influenced by the method of preparation. Several studies have been done to demonstrate the retention of vitamins after different methods of preparation. For instance, as a result of their highly unsaturated structure, carotenoids are sensitive to heat, oxygen and light and thus especially susceptible to degradation.[31] Other vitamins that are also labile are vitamin C, folate and thiamine. To compensate for these losses, compilers of food composition databases need to make use of retention factors. In the 'Supplement on Vegetables and Fruit', retention factors available from the USDA were used for the calculation of the vitamin content of cooked food if values were only available for the raw food item, since retention factors are not presently available for typical South African foods.[7]

Imputation

Compilers of food composition databases make use of imputation as another method for determining the nutrient content of food. This entails estimating the value of the missing nutrient by using the information from similar foods and making 'best choices' for adding the necessary information to the database.[18] Deriving imputed values from incomplete or partial analyses of food, e.g. carbohydrate by difference, can also be useful.[13] Although this is not a preferred method, it is better than having missing information in a food composition database, especially when the database is used for research purposes.[30]

Food composition databases and literature

Information on the nutrient composition of foods is available from international food composition databases and scientific articles. The latter are also often used for compilation purposes. However, using information from other databases has its limitations. Often the information is not very specific with reference to the different cultivars of agricultural produce, e.g. fruit and vegetables, or the definition of meat cuts may differ between countries. When detailed descriptions of the data are not available, the nutrient values borrowed from other databases are a generalisation and lack specificity, e.g. the different composition of cultivars for fruit or vegetables. It should also be pointed out that sometimes the names used in food composition databases can have different meanings, e.g. "grasshopper" in the USA means an alcoholic beverage with crème de menthe, whereas in South Africa it will be interpreted as an insect eaten as a food.[18] There are several other examples of where a name given to a food can have different meanings in different countries.[18]

Sources of information

As many different methods are used for the compilation of the nutrient composition of foods in SAFOODS, the main source of the nutrient information is declared and made available in printed tables. Additional information on the reference sources for individual nutrients is available from the compilers of SAFOODS. Users of food composition tables are advised to always check the source of the information on the nutrients. This is especially important when comparing the nutrient values of the same food prepared in different ways, e.g. raw/cooked or with/without skin. The nutrient values for the same food could differ, not only as a result of the method of preparation or state (with or without skin) of the food, but also because the reference sources of the information differ.

Nutrients in the South African Food Data System (SAFOODS)

Nutrient values in the food composition database represent average values and can never be an exact reflection of the nutrient content of the food item at all times. As already mentioned, different factors can influence the nutrient composition of a food item.[18] The South African Food Composition Database contains information on 146 food components, which include moisture, ash, energy, macronutrients, micronutrients, amino acids and fatty acids.Little information is, however, available on constituents/nutrients such as caffeine, phytate and different carotenoids because of the lack of sufficient data. Provision has been made for these nutrients in SAFOODS to enable the compilers to update the information as it becomes available.

The unit of measurement for the different nutrients in SAFOODS is given per 100 g of edible food. When a zero value is indicated for the food item it means that the nutrient is not present in the food item. Sometimes the nutrient is present in a food item, but at such low concentrations that it was not possible to determine the content at the detection level of the analytical method that was used. In this case the value is indicated by the abbreviation 'tr', meaning that a trace of the nutrient is present in the food item. If no information is available either by chemical analysis, calculation or by using the 'best guess' value, a blank space appears in the food composition tables, indicating missing information. In this regard, it is to be noted that missing values can be responsible for systematic errors of an underestimation of the intake of a specific nutrient.[30] It has been shown, for instance, that if missing values are treated as zero, e.g. in the case of fibre, there was an underestimation of fibre intake of up to 20% in comparison to when the FIBRE value of a similar food is used to record the fibre value for the food item with the missing information.[30]

Information on the energy, macronutrient and micronutrient composition of foods is presented in the Condensed Food Composition Tables for South Africa.32 The energy content of food is calculated by using defined conversion factors (Table II). The available carbohydrate and dietary fibre information is presented separately in SAFOODS. Users of the tables should take note of this when using the food composition database to calculate the energy content of a food or diet, by using the conversion factors for carbohydrate, protein and fat. In the 1991 Tables, the energy content of food was not always calculated by making use of the conversion factors, but when data was borrowed from other sources the energy content was recorded as provided in the original source.[4] In many food composition databases, total carbohydrate is calculated by difference, by subtracting the moisture, protein, fat and ash value from 100 to give the percentage of total carbohydrate.[13] The available carbohydrate is calculated by difference by subtracting the total dietary fibre value from the total carbohydrate value.[13] In SAFOODS, most of the values for available carbohydrate are calculated by difference.

Table II: Conversion factors for energy[14]

Nutrients	kJ/g	kcal/g
Protein	17	4
Total carbohydrate (available carbohydrate plus dietary fibre)	17	4
Fat	37	9
Alcohol	29	7

The vitamin A content of the food in the database is presently expressed as µg retinol equivalent (RE) per 100 gram of food, and therefore represents the retinol equivalent of the food item. In SAFOODS, the following conversion factors were used to convert the carotenoid content of fruit and vegetables to retinol equivalents: 1 µg retinol is equal to 6 µg β-carotene or 12 µg α-carotene or 12 µg β-cryptoxanthin.[7]

Frequently asked questions on the nutrient information in the South African Food Data System (SAFOODS)

Answers to questions asked most frequently about the nutrient composition of foods are generally found in the introduction section of the printed food composition tables or in the documentation that accompanies the software program. Failure to read this information can result in misuse of the data and thus misinterpretation of research results.

One of the most frequently asked questions is why the SFA, MFA and PUFA content of a food item does not add up to 100% of the total fat content of the specific food. The reason for this has already being explained, namely that the total fat content of a food item consists not only of the aforementioned fatty acids, but also of non-fatty acid components such as glycerol (the backbone of the triacylglycerol molecule), sterols and phospholipids.

Limitations of information in food composition databases and the South African Food Data System (SAFOODS)

The nutrient composition of foods presented in food composition databases should never be treated as absolute values for a specific food, as these values represent averages. As mentioned previously, many factors influence the nutrient composition of foods and, in all likelihood, no two apples, for example, will have the same nutrient content. The variability of the nutrient composition of foods is therefore one of the limitations of using information from food composition databases. This is especially important when exact information is needed, e.g. for intervention trials when the effect of a specific nutrient on health outcomes is being investigated.

Information on the nutrient composition of fast foods is limited in SAFOODS at the moment. The database also does not cater extensively for culture-specific recipes. Moreover, not all the nutrient values for the foods in SAFOODS are of South African origin. Although efforts are being made to increase the number of nutrient values of food of South African origin, this is a challenging task because of budget and human resources constraints. The aim, however, is to analyse at least those foods that are of main concern to the specific health and disease-related issues in the country.

Advantages of country-specific food composition databases and the South African Food Data System (SAFOODS)

A country-specific food composition database, like SAFOODS, aims to include as many as possible foods produced in the country for which nutrient values were generated locally. In addition, information is included on typical South African dishes and preparation methods. The latter has advantages, especially for those using the database for research purposes. It enables researchers to find the best fit between the foods consumed by the study participants and the foods for which information is available in the food composition database.

Information in SAFOODS is made available to the South African nutrition fraternity in the format of printed tables and software programs. These products provide the user with excellent tools to: (a) look up the nutrient content of a food item; (b) compare the nutrient content of foods; (c) search for the best food choices for specific nutrients; (d) teach students about the nutrient content of foods; (e) compile and analyse menus for institutions; (f) assess the nutrient intake of patients and compile diets for them; (g) use the data for nutrition-related research purposes, e.g. large epidemiological studies such as the NFCS; and (h) use the data to a limited extent for labelling purposes, as long as no health claims are made.

Future of the South African Food Data System (SAFOODS)

The aims remain that of continuing with the compilation of food composition data for South Africa and to extend current activities. Updating the food composition database more regularly is one of the goals, but this can be achieved only if more role players become involved in generating South African data on the nutrient composition of foods eaten in the country. It therefore is hoped that other role players and the food industry will play a greater role in this regard in the future. The South African food industry generates a significant amount of information on the nutrient composition of foods for labelling purposes. If this information were added to SAFOODS the percentage of South African data could be increased significantly. Furthermore, in view of the paucity of information on the nutrient composition of indigenous foods and special dishes eaten in South African, one of the main objectives of the compilers of SAFOODS is to include this information in the future. These developments will undoubtedly help nutrition professionals in their efforts to better evaluate the nutrient intake of their clients/patients and the country's population.

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