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INFOODS contributions to fulfilling needs and meeting challenges concerning food composition databases

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Abstract

Food composition data play a key role in most nutrition related activities. The International Network of Food Data Systems (INFOODS) has contributed to improving the availability and quality of food composition data worldwide. INFOODS activities include publication of regional and international food composition tables and databases (e.g., Food Composition Database for Biodiversity) and guidelines. Capacity development is an on-going activity through postgraduate classroom courses and distance-learning modules. Training and awareness-raising through these efforts has led many sectors (e.g., agriculture, health, environment, food regulatory) to appreciate the importance of quality food composition data as the basis for policies and decision-making.

Keywords: food composition; INFOODS, biodiversity, data quality, capacity building

1. Global nutrition, food and agriculture situation

Despite global agricultural production that is theoretically sufficient to feed the world's population, about one billion people are hungry [1] and two billion suffer from micronutrient deficiencies [2]. In contrast, excessive consumption of energy-dense, nutrient poor food in combination with a decrease in physical activity has led to 1.4 billion adults and school children who are overweight and half a billion who suffer from obesity [3]. In the past, it was assumed that when individuals reached energy adequacy, their requirement for all other macro- and micronutrients would be covered automatically. However, this assumption is almost always incorrect. Agricultural programs and policies often aim to increase the production of staple crops as they are essential to alleviate hunger and energy deficiency; however they are typically insufficient to combat all micronutrient deficiencies. Therefore, additional efforts are needed

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to address all forms of malnutrition (i.e. undernourishment, micronutrient deficiency and overnutrition) by increasing the availability and affordability through production or import of a wide range of diverse foods that are needed for a healthy diet. Such foods include fruits, vegetables and some animal source foods.

Nomenclature:

FB – food-based
FC – food composition
FCT – food composition table(s)
FCDBMS: food composition database management system

Another aspect to be considered is food biodiversity, which can be a useful tool in the fight against malnutrition, giving consumers access to wider dietary diversity. The potential of indigenous, neglected or underutilized food crops and gathered foods to improve dietary diversity remains largely unknown and underexploited. Information on the contribution of such foods to people's diets and nutrient intakes is also scarce as such foods are often not included in food consumption surveys and in the FAO Food Balance Sheets [4]. Recent studies have shown that nutrient values may vary up to 1000 times among different varieties of the same food, especially for micronutrients. This means that the nutrient content can vary as much among varieties of the same food as among different foods. Intake of one variety rather than another can mean the difference between micronutrient deficiency and adequacy [5–7]. Therefore, the production and consumption of those varieties with high nutritional value should be favored, especially those rich in nutrients that the population may be deficient in. Furthermore, it is important that the nutrient content is one of the criteria agriculture policy makers and practitioners use to ensure better and more nutritious crop varieties are available for consumption [8].

Many countries and international agencies attempt to combat malnutrition with short-term health and nutrition interventions such as supplementation or fortification. In recent years, increasing doubts have been articulated on the sustainability of supplements [9,10]. Furthermore, food not only contains nutrients but also many bioactive compounds that have not yet been fully explored. Additionally, it is thought that nutrients interact differently when consumed in their original form through foods and thus, are able to provide important benefits that supplements and fortificants cannot deliver [11]. FAO and its partners, on the other hand, concentrate their efforts in decreasing malnutrition through foods, i.e. by increasingly linking agriculture, biodiversity and nutrition to achieve sustainable solutions, e.g. sustainable diets [12].

Increasingly, the literature supports the success of food-based (FB) approaches, which include dietary diversification and modification, fortification and biofortification [13]. The success of homestead or community gardens as a cost-effective means of combating micronutrient deficiency, especially vitamin A deficiency, has been demonstrated by studies coordinated by Helen Keller International in Bangladesh, Nepal, Cambodia and the Philippines, where an integrated approach including animal husbandry and nutrition education were used [14]. Another well-known example of a successful FB-approach is that of orange-fleshed sweet potato, where high carotenoid varieties were identified and promoted to agricultural extension to reduce vitamin A deficiency [15]. A recent systematic review that looks at household food production strategies on the health and nutrition outcomes of women and young children concludes that the existing evidence base supports the hypothesis that agricultural strategies improve intakes of micronutrient-rich foods by women and young children when nutrition education, gender and nutrition objectives are explicitly stated [16].

2. Need for food composition data in nutrition, health and agriculture

Food composition (FC) data play an essential role in all sectors of nutrition, such as nutritional epidemiology, diet formulation, dietetics, nutrient requirements and labeling [6,14,17–25].

Furthermore, FC data should become progressively more important also for agriculture, as nutrition-sensitive agriculture comes increasingly into the spotlight. For the success of the food-based approach mentioned above, compositional and consumption data are vital, not only for staple crops and a few main foods, but also for wild and underutilized foods. Such data are also needed if food biodiversity is to be successfully used to combat malnutrition.

Food composition data for biodiversity, i.e. data at the variety, cultivar and breed level, are not widely available. So far the use of compositional data for common foods was sufficient for most purposes, but with rising recognition of food biodiversity it is realized that more compositional studies are needed that focus on this aspect. This lack of information regarding nutrient contents of cultivars, varieties as well as wild and underutilized foods may be directly affecting farmers, consumers and the environment, because people are less likely to cultivate or consume these foods. Further, negative impacts on a population level arise when nutrition and health programs are based on national food composition databases which do not reflect the nutrient content of the varieties actually consumed.

As the negative impacts of foods high in saturated fats, trans-fatty acids, sodium and sugar (particularly with regard to the rise in non-communicable diseases) become increasingly well-accepted, the need for food composition data on such foods is obvious.

Globally, the consumption of ultra-processed foods and of food supplements is increasing [26] but they are often not included in FCTs, especially processed foods that are fortified or enriched. This leads to errors in nutrient intake estimations. When fortified foods and supplements are not considered, the nutrient intake of micronutrients is heavily underestimated, leading to the wrong conclusions that more foods need to be fortified and/or supplements are needed. On the other hand, an increasing proportion of the population is above the upper limit (UL) for certain micronutrients due to the consumption of fortified foods and supplements [27].

The Codex Alimentarius standard 2012 of making nutrition labeling mandatory for all pre-packaged foods [28,29] is another key reason as to why there is an urgent need for high-quality and comprehensive coverage of food composition data in national and regional FCTs.

3. Challenges to obtaining high-quality food composition data

High-quality food composition data are needed and should be publicly available to users. Such data should be in a user-friendly format, and cover users' needs with regard to food and component coverage.

Many users of food composition databases and tables are not aware that food composition data can vary significantly either because of real differences in the nutrient content or because of artifactual differences. Real differences in nutrient content of foods can arise due to environmental and processing influences, recipe formulation, cooking methods, biodiversity or differences among products from different producers. Artificial differences may be introduced to data due to data quality, sampling, analytical methods, calculation methods or data expression [20].

Three pillars are needed to ensure that high-quality food composition data are generated, compiled, disseminated and used:

1) International standards, guidelines and tools on the generation and compilation of food composition data must be developed and used,
2) National and/or regional food composition programs must exist, which are updated regularly, and
3) Professionals must be trained in all aspects related to food composition.

The first pillar, i.e. the development of international standards, guidelines and tools, was made possible with the establishment of the International Network of Food Data Systems (INFOODS) in 1984. The

European Food Information Resource Network (EuroFIR) was established in 2005 with the goal of developing additional standards and guidelines focusing on the European context.

The second pillar comprises effective national and/or regional food composition programs to ensure the generation, compilation and dissemination of relevant, reliable and up-to-date national and/or regional food composition databases and tables. Ideally, food composition databases should be constructed using the above-mentioned international standards and should be maintained over time. Well-designed tables and databases should include a good selection of food components and cover most of the foods commonly consumed. However, this is often not the case as many tables only include raw foods and cover only a small number of nutrients, and many lack processed and fortified foods as well as supplements. In many countries, high-quality analytical food composition data are still missing on commonly consumed foods as well as on underutilized and wild foods and on the different varieties. Often, only proximate values are analyzed, and fiber is unfortunately often analyzed using the crude fiber method, which is unsuitable for human nutrition. Carbohydrates are rarely analyzed but often calculated by difference. Fortunately, total carbohydrates by difference (i.e. carbohydrates including dietary fibers) has been phased-out in most of the recently published food composition tables/databases (except e.g. the food composition database of the US Department of Agriculture [30]). However, analytical data are often missing on vitamins, and to a lesser extent, on minerals.

Many developed countries and some developing countries have institutions responsible for the development, maintenance and dissemination of food composition tables and databases. They have a defined budget and staff assigned for these tasks, and as a result, they regularly publish updated food composition tables and databases. On the other hand, in most developing countries and some developed countries, tables are often produced within projects or as a private initiative, i.e. not within an institutional framework. Such tables are not always maintained over time. Therefore, many developing countries either do not have a food composition table, or have one that is many years old, and is thus out-of-date and contains inadequate data [31]. In many cases, the political and institutional support is lacking to develop and maintain food composition programs over time.

The third pillar is the need for training professionals and students in the different aspects of food composition. Training is taking place via international courses, and increasingly through distance and e-learning tools. However, food composition is still rarely included in the formal training of nutritionists and other professionals [32] which would be the most effective means to enlarge the number of professionals with solid food composition knowledge.

4. Opportunities

Even though much still needs to be done in the field of food composition, we must not forget that much has been achieved in the last 30 years. Many international standards and guidelines now exist, as well as training opportunities and tools, e.g. for the compilation of databases. International collaboration is possible, and increasing amounts of analytical data (including on biodiversity) are produced and some are published in the international literature. Furthermore, through the internet a greater number of food composition tables and databases are now accessible and freely available – 20 years ago internet data was mainly from the US Department of Agriculture..

Countries and donors, after a period of disinterest in food composition, seem to have become more interested again in the topic, probably due to the new labeling requirements and the higher profile of nutrition in general, as well as the rising awareness that some of our foods and diets need to change because of the rise of non-communicable diseases (e.g. salt as a risk factor for hypertension) [33,34].

5. International collaboration – demonstrated through the example of INFOODS

The aim of INFOODS (International Network of Food Data Systems), since its establishment in 1984, is to stimulate and coordinate efforts to improve the quality and availability of compositional data globally. INFOODS is organized as a distributed resource with regional data centers which sponsor national branches. In addition, there is a global coordinator (since 1999 at FAO) and regional coordinators [35]. Through this network, INFOODS has established standards, guidelines and tools on the generation, compilation and use of food composition data, assisted countries in developing their food composition tables and contributed to capacity building. It is the philosophy of FAO and INFOODS to provide wide access to its guidelines, standards and tools. Therefore, they can all be downloaded free-of-charge from the INFOODS website. The INFOODS website was updated and improved in 2012 following new standards in communication to make it more attractive and user-friendly.

The aim of INFOODS (International Network of Food Data Systems), since its establishment in 1984, is to stimulate and coordinate efforts to improve the quality and availability of compositional data globally. INFOODS is structured into different regional data centers which have national branches. In addition, there is a global coordinator (since 1999 at FAO) and regional coordinators [35].

5.1. Standards, guidelines, tools, and major publications

The first international standards on food composition were developed by INFOODS on component identifiers, food nomenclature, data interchange and compilation [36–39], which formed the basis of all subsequent work on food composition. Other international standards were generally based on the early work of INFOODS, and strived to further develop and expand the initial work. Some examples are the work by the EuroFIR (http://www.eurofir.net/), or previously EUROFOODS.

Since 1989, over 800 INFOODS component identifiers [36,40], also called tagnames, have been developed. Many more tagnames are being added as new components are analyzed and new methods developed. EUROFOODS [41] and EuroFIR developed their own component identifier systems and EuroFIR regularly publishes new sets [42,43]. Since 2009, INFOODS and EuroFIR have been regularly meeting and exchanging ideas with the objective of harmonizing component identifiers as much as possible within the restrictions of the two systems. Topics discussed include the use of symbols and the differentiation of methods and/or expressions in the attribution of component identifiers.

For example, although INFOODS made some early propositions concerning food nomenclature, [37,38,44], these were not further developed. Thereafter, LanguaL [45] was adapted for food composition purposes. *LanguaL* is a language independent thesaurus, which provides a standardized vocabulary for the description and classification of foods, which comes with software [46], and is the basis of EuroFIR's interchange and eSearch functions [47].

Interchange of food composition data has always been seen as important, and the first INFOODS proposition was developed by Klensin [48]. It was adapted and expanded by the regional INFOODS data centers of Scandinavia (NORFOODS) [49], Central and Eastern European countries (CEECFOODS) [50], European countries (EUROFOODS) [41], INFOODS/FAO [51], and EuroFIR [47,52].

The first INFOODS guidelines on compilation of food composition data were published by Rand et al. in 1991 [39]. This practical guide was complemented by more recent guidelines which further assist countries in developing and using food composition databases and tables in a standardized way: The FAO/INFOODS Food Matching Guidelines [53], and the FAO/INFOODS Guidelines on Checking Food Composition Data prior to the Release of a User Database [54] and the FAO/INFOODS Guidelines on Conversion Among Different Units, Denominators and Expressions [in preparation]. The need for new guidelines was identified during the preparation of the West African Food Composition Table [55] and the FAO/INFOODS Food Composition Database for Biodiversity - Version 2.0 [56], where different compilers were working on the tables and not all of them had the same understanding of how to deal with certain issues. In addition, a comprehensive guide on checks to be carried out on food composition data prior to their publication was not available. These gaps have now been filled by the new FAO/INFOODS guidelines, and it is hoped that they will improve the quality of published food composition data. Other FAO/INFOODS guidelines are planned, for example, on recipes, nutrient retention factors, sampling and selection of food composition data.

We also wrote to editors of scientific journals to draw their attention to a minimum data quality required to enable data from scientific articles to be used in the compilation of compositional data.

FAO/INFOODS has also published the Compilation Tool together with a user manual [57] (http://www.fao.org/infoods/infoods/software-tools/en/). It is a simple food composition database management system (FCDBMS) in MS Excel to allow countries to store, document and manage food composition data electronically in a standardized manner and according to INFOODS standards. Currently, the Compilation Tool version 1.2.1 includes 151 components with their INFOODS tagnames, three recipe calculation systems with their formulas, a set of nutrient retention factors, examples of calculated recipes and some compositional data with their documentation. The flexibility of the Compilation Tool should allow users, according to their specific needs, to add components, nutrient retention factors or worksheets for expressing data with denominators other than 'per 100 g edible portion' which is the default denominator. The Compilation Tool fills a global gap as no such FCDBMS is currently available for global use. EuroFIR currently uses transport packages [47,52]. Presser et al. [58] in Switzerland are developing and field testing FoodCase, which could become another global FCDBMS in the future, and will be available through EuroFIR and/or INFOODS.

INFOODS and FAO have also published important reference documents such as the 'Food composition data – production, management and use [20], the so-called bible on food composition, which was also published in Spanish (2006), French (2007) and Korean (2008). Prior to that, the book Food Composition Data: A User's Perspective [59], published with help from FAO, was an important collection of challenges and uses of food composition data.

FAO, often in collaboration with WHO including Codex Alimentarius, has published reports on food standard components requirements such as carbohydrates, fat, protein, and vitamins [60–63], (e.g. definition of dietary fiber or vitamins or energy calculations). These standards are used for food labeling, and often have implications for compiling food composition databases [28].

5.2. Food composition data and databases/tables

The Journal of Food Composition and Analysis (JFCA) was the official journal of INFOODS from 1987 to 2010. The journal continues to be published, but without FAO or INFOODS involvement. Scientists also have the possibility of presenting their new findings on food composition at the biannual International Food Data Conference (IFDC), which is the official INFOODS conference [64].

Analytical food composition data should be of high quality. One of the features of high quality data is laboratory quality assurance, including good performance and the right use of the appropriate analytical method. Therefore, the Southeast Asian INFOODS regional data center (ASEANFOODS) has organized several proficiency testing protocols on vitamins and also developed reference material [65]. The South Asian data center (SAARCFOODS) is planning to start a proficiency testing of proximate analysis. FAO has also made some progress in this regard. For example, within a FAO technical cooperation project in 2002-2004 in the South Pacific, the laboratory capacity in food composition was strengthened through new equipment and training, and accreditation was obtained. ASAENFOODS also published in 2011 the ASEAN Manual of Nutrient Analysis, which includes steps to follow when carrying out major food analysis. Future plans include creating a new INFOODS website on laboratory-related issues such as a list of laboratories carrying out food analysis and links to websites on accreditation and analytical methods. In addition, INFOODS will be publishing a comprehensive list with all INFOODS component identifiers, in which the corresponding analytical methods will be indicated.

In the past, FAO published regional food composition tables [66]. When INFOODS was established, the regional INFOODS data centers became responsible for coordinating the development and publication of regional and national food composition tables and databases. As a result, several food composition tables were published: ASEANFOODS (2000) [67], Latin America (LATINFOODS) (2002) [68], Pacific Islands (1994, 2004) [69,70], Lesotho (2006) [71], Brazil (2008) [72] and Armenia (2011) [73]. More recently, FAO took the lead on the development of two tables for West Africa: Composition of selected foods in West Africa [74] and West African Food Composition Table [55]. More regional tables are needed as many are out-of-date and should be updated.

In order to calculate nutrient values of recipes and cooked foods with a higher precision, more analytical work is needed on retention factors for micronutrients in different parts of the world. These data should then be compiled into a database which would be the basis for regional nutrient retention factors. INFOODS is currently working on protocols. The next step involves identifying appropriate laboratories and donors.

Many compilers copy data from published food composition tables and databases. Often, it is not possible to distinguish which of these data are analytical data and which ones are estimated or calculated. Therefore, in order to allow compilers to use purely analytical data for their compilations, INFOODS decided to publish databases that contain solely analytical data. In 2010, the first version of the FAO/INFOODS Food Composition Database for Biodiversity (BioFoodComp) was published, which included analytical data for different plant varieties/cultivars and animal breeds as well as for underutilized and wild foods. The database was updated annually and version 2.0 of 2012 included 6411 data lines of different foods and 451 components and many new features [31,75]. In 2013, it is planned to publish the first version of the FAO/INFOODS Analytical Food Composition Database which will include analytical data on general foods.

In addition, dietary assessment requires reliable data on both food consumption and food composition. To improve data quality and harmonization, two tools were published in 2011 for that can be used by food consumption data assessors: the above mentioned FAO/INFOODS Food matching guidelines [53] and the FAO/INFOODS Density Database [76]. It is intended to update them regularly as new data become available or new needs are identified.

5.3. Biodiversity

Biodiversity has received more attention in the last 10-15 years including in food composition [5,7,75]. FAO/INFOODS, together with other partners, developed two Nutrition Indicators for Biodiversity, one on food composition [77] and one on food consumption [78] to stimulate the production, collection and dissemination of food composition and consumption data taking biodiversity into account. The indicators can also be used as an advocacy tool to promote awareness of the importance of food biodiversity, including wild and underutilized foods. By the end of 2011, more than 12800 foods have been counted to meet the criteria for the Nutrition Indicator for Biodiversity on food composition and 4900 foods for the indicator on food consumption [79]. In addition, the FAO/CINE book, "Indigenous Peoples' food systems: the many dimensions of culture, diversity and environment for nutrition and health" [80] outlines the importance of biodiversity and well-functioning food systems. In line with the topic, in 2009 the Bangkok Declaration from the 8th International Food Data Conference came out and in 2010 the AFROFOODS declaration was issued [81]. Both re-iterate the need for food composition data including on biodiversity for the renaissance of food systems. By launching the FAO/INFOODS Food Composition Database on Biodiversity (BioFoodComp) in 2010, FAO/INFOODS have responded actively to the recommendation of fostering the analysis and compilation of nutrient data at the taxonomic level below species [31]. It is hoped that compilers include these types of data into national food composition tables, aiming to better evaluate the contribution of biodiversity to nutrient intakes.

5.4. Capacity development

Since 1992, FAO/INFOODS has organized or co-organized over 20 international training courses. Over 600 professionals have been trained, contributing to the development of capacity in food composition generation, compilation and use around the globe [82]. However, classroom-based training is not sufficient to reach the ever increasing number of professionals in need of knowledge on food composition, especially in developing countries [83–85]. Therefore, the distance learning tool Food Composition Study Guide was published in 2009 to reach more professionals in a cost-effective manner. It is available in English, French and Spanish [32,86,87] together with 12 PowerPoint presentations that summarize the main points of the modules [88]. The Study Guide is a good means of filling the existing global training gap in food composition data and can be used in universities, laboratories, courses and by self-learners, either as distance learning or in classrooms. An entire module of the Study Guide is devoted to biodiversity and the growing need for knowledge about the composition of foods based on varieties, cultivars and breeds. In addition, e-learning tools on food composition analysis were developed [89].

6. Conclusion

In response to needs and challenges in food composition FAO and INFOODS assisted countries in developing their national food composition programs and tables through developing guidelines, tools, databases and through technical assistance. These contributed to an increasing number of food composition tables/databases, some of which are found on-line and free-of-charge, following the US example (http://www.fao.org/infoods/infoods/tables-and-databases/en/). However, analytical data are still missing for many foods especially in developing countries, and particularly on food biodiversity, processed foods, fortified foods and supplements. FAO and INFOODS will continue their efforts to increase quality and availability of food composition data.

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