DISSERTATION

Titel der Dissertation

Development, evaluation and impact assessment of the Food Composition Study Guide

angestrebter akademischer Grad

Doktorin der Naturwissenschaften (Dr. rer.nat.)

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Wien, am 13. April 2010

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Acknowledgements

I am very grateful to O. Univ.-Prof. Dr. Ibrahim Elmadfa who proposed that I do my doctorate with him and who gave me the opportunity to field test different food composition course approaches at the Universities of Vienna, Austria, and of Hebron, Palestine. He also guided me smoothly throughout the thesis while giving constructive comments.

I would also like to express my sincere gratitude to my supervisor Barbara Burlingame at FAO who encouraged me to do my doctorate, who gave me numerous comments and suggestions for improvements of the Food Composition Study Guide and the thesis, and who co-authored several articles with me on the topic. I am also grateful to my FAO colleague Sally Berman for her assistance in the development of the Study Guide and for introducing me to instructional design.

I would also express thanks to all those who contributed to the development of the Food Composition Study Guide, particularly to all peer reviewers (Gary Beecher, Eliana Bistrich Giuntini, Rakesh Bhardwaj, Carol Byrd-Bredbenner, Isabel Castanheira, Paolo Colombani, Roger Djoule, Marie Claude Dop, Lois Englberger, Nino dePablo, Jean Francois Hausman, David Haytowitz, Paul Hulshof, Venkatesh Iyenger, Kunchit Judprasong, Jehangir Khan Khali, John Klensin, Harriet Kuhnlein, T. Longvah, Alison Paul, Pamela Pehrsson, Jean Pennington, Janka Porubska, Prapasri Puwastien, Hettie Schönfeldt, Louwrens Smit, Ian Unwin, Ana Vasquez-Caicedo, Elizabete Wenzel), to those who contributed to its content (Marie Luccioni, Edouard Oddo, Enrica Biondi, Prapasri Puwastien) and those who tested the modules: George Annor, Rekia Belahsen, Natasha Danster, Heinz Freisling, Melanie Fröhler, Ingrid Führhacker, Verena Hasenegger, Sonja Kanzler, T. Longvah, Susanne Lüftenegger, Katharina Maierhofer, Elinor Medhammar, Beatrice Mouille, Verena Nowak, Nino dePablo, Esther Sakyi-Dawson, Annalisa Sivieri, Francisca Smith, Renee Sobolewski, Barbara Stadlmayr, as well as the participants in the food composition courses in Bratislava, Slovak Republic (2008), Teheran, Iran (2008), Cotonou, Benin (2009) and Akkra, Ghana (2009) and in Vienna, Austria (2008, 2009). I also would like to thank Oman Bolbol for the cover design and Giuseppina Di Felice for the layout of the Food Composition Study Guide.

I also thank Karin Nichterlein, Rachel Sauvinet-Bedouin, Marie Claude Dop and Heinz Freisling for reviewing the manuscript and providing me with very useful comments, and Isabella McDonnell and Giuseppina Di Felice for their secretarial assistance. I would like to express my appreciation to Verena Nowak for all her help.

I am also grateful to the Director of the Nutrition and Consumer Protection Division Ezzeddine Boutrif and to the Food and Agriculture Organization of the United Nations (FAO) who granted me time and funds to carry out my doctorate.

Last but not least, I would like to thank my family, especially my husband Bruno, and my friends for their support and encouragement.

Abbreviations

ANS	Scientific Panel on Food Additives and Nutrient Sources added to Food of the European Food Safety Authority
APO	Associate Professional Officer
BFHI	Baby-Friendly Hospital Initiative
CD ROM	Compact disc, read-only-memory
ECTS	European Credit Transfer and Accumulation System
EFSA	European Food Safety Authority
EuroFIR	European Food Information Resource Network
EUROFOODS	Regional data centre of INFOODS covering Europe
FAO	Food and Agriculture Organization of the United Nations
FCDB	Food Composition Database
FFQ	Food Frequency Questionnaire
IARC	International Agency for Research on Cancer
IDF	International Dairy Federation
INFOODS	International Network of Food Data Systems
IOM	Institute of Medicine of the National Academies
IUNS	International Union of Nutritional Sciences
JECFA	Joint FAO/WHO Expert Consultation on Food additives and Contaminants
LanguaL	Langua aLimentaria (language of food)
NIN	National Institute of Nutrition, Hyderabad, India
OECD	Organisation for Economic Co-operation and Development
OELS	Oesterreichischer Lebensmittelschluessel (Austrian Nutrient Database)
OHI	Operation Handicap International
UNU	United Nations University
USDA	United States Department of Agriculture
VLAG	Advanced Studies in Food Technology, Agrobiotechnology, Nutrition and Health Sciences
WHO	World Health Organization

1. Introduction

Relevant, reliable and up-to-date food composition data are of fundamental importance in nutrition, dietetics and health, but also for other disciplines such as food science, biodiversity, plant breeding, food industry, trade, and food regulation (Greenfield and Southgate, 2003; FAO, 2008). High-quality food composition data should be representative of the national food habits and consumption pattern, and they should be generated according to international guidelines to make them comparable and reliable. Well-designed tables and databases should include a good selection of food components and most of the consumed foods. However, this is often not the case as many tables only include raw foods and only a small number of nutrients, and many tables lack processed and fortified foods. They also need to be updated regularly to take changes in the food supply into account as well as the availability of new analytical methods (Greenfield and Southgate, 2003).

Without food composition data, the following tasks cannot be accomplished (Willet, 1998; Hagenimana, 1999; Riboli *et al.,* 2002; Englberger *et al.,* 2003; Greenfield and Southgate, 2003; IOM, 2003; Burlingame, 2004; FAO/WHO, 2004; Vorster *et al.,* 2007; Toledo and Burlingame, 2006; Pennington *et al.,* 2007):

- calculating nutrient intake estimations of populations using food consumption surveys and assessing their nutrient adequacy;
- developing nutrient requirements;
- carrying out epidemiological research on the relationship between nutrient intake and disease;
- producing nutrition labels;
- formulating institutional and therapeutic diets;
- promoting nutritionally-important plants and animals (and their different cultivars, varieties and breeds) for breeding and agricultural production programmes aimed at improving human nutrition and health; and
- informing consumers about good food choices.

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 artificial differences. Nutrient contents in foods can vary because of environmental and processing influences such as feed, soil, sunshine, varieties, storage conditions, processing, fortification, market share, varieties, or because of differences in recipes and local food traditions. Artificial differences may be introduced to the data due to data quality, sampling, analytical methods, calculation methods or data expression (Deharveng et al., 1999; Greenfield and Southgate, 2003). In addition, recent studies have shown that nutrient values may vary by three to 1000 times among different varieties of the same foods. This means that the nutrient content of foods can vary as much among foods as among varieties of the same food. This is the reason for the recent introduction of food biodiversity into food composition (Englberger *et al.,* 2003; Burlingame et al., 2009). Some people may argue that foods have similar composition among countries due to globalization. However, as the composition of foods is influenced by all the above-mentioned factors and as these factors usually vary among countries, significant differences in nutrient values normally exist among countries. In addition, each country has its own country-specific foods and recipes, commercial foods of the same brandname food can have varying composition due to taste or fortification across borders, and consumption patterns are different among countries and may change differently over time. Therefore, normally each country has specific data needs and a national food composition database and table can be justified, even though some of the foods might be the same or similar across countries.

Furthermore, many users are not aware of the different nutrient contents between e.g. raw, cooked and processed foods or between the different expressions and definitions of nutrients and their influence on nutrient values. This is the case for many vitamins (e.g. Vitamin A, D or E, or folate versus folic acid) and even for macronutrients. For example, carbohydrates have four major expressions each having different values, or dietary fibre is analysed by mainly three different analytical methods, which again each generates different results. For all these reasons, people need to realize that food composition data are not simple numbers but that a lot of knowledge is needed to generate, compile, update and use these data adequately.

Many countries have food composition tables and databases (INFOODS, 2010 a), but most of them contain incomplete, outdated and unreliable data. On the other hand, there are still many developing and some developed countries without such tables or databases. They have to use food composition data from other sources, for example the publicly available United States Department of Agriculture (USDA) database (2010 a), or a table from a neighbouring country (e.g. Austria uses the German food composition tables) or an existing but out-of-date food composition table such as the Food Composition Table for Use in Africa (FAO and USDHEW, 1968) which is still widely used in African countries.

In most cases, the borrowed food composition data are not evaluated for adequacy and do not take into consideration the differences in food composition due to variety, environmental effects or type of local processing methods among countries. In addition, food composition tables and databases are developed based on different concepts making food composition data incomparable across countries or over time (Deharveng *et al.,* 1999; Greenfield and Southgate, 2003).

These borrowed data may be inadequate for the above-mentioned purposes and, consequently, the calculated nutrient intake estimations will be also of low quality and might contain errors. Today, in many countries nutrient intake estimations are underestimated because fortified foods and supplements (containing vitamins and minerals) are consumed but are not sufficiently, if at all, included in food composition databases (Greenfield and Southgate, 2003). Inadequate food composition data and their use may then lead to erroneous research results, wrong policy decisions (particularly in agriculture, nutrition and health), misleading food labels, false health claims and inadequate food choices (Burlingame, 1998).

Three pillars are needed to ensure that high-quality food composition data are generated, compiled, disseminated and used: (1) international standards on the generation and compilation of food composition data are developed and used, (2) national and/or regional food composition programmes exist and are updated regularly, and (3) professionals are trained in all aspects related to food composition.

The first pillar was made possible with the establishment of the International Network of Food Data Systems (INFOODS) in 1984, leading to significant improvements in international standards and guidelines for the collection, compilation and interchange of food composition data (Klensin *et al.,* 1989; Truswell *et al.,* 1991; Rand *et al.*, 1991; Klensin, 1992; FAO, 2003; FAO, 2004). In addition, INFOODS and FAO published important reference documents such as 'Food composition data – production, management and use (Greenfield and Southgate, 2003) and the Food Composition Study Guide (Charrondiere *et al.,* 2009 a, b). These standards and guidelines resulted in improved quality and availability of food composition data worldwide. The European Food Information Resource Network (EuroFIR) developed additional standards, guidelines, and training materials for food composition (e.g. Møller et al., 2008 a, b, c; EuroFIR, 2010 a, b; LanguaL, 2010), focusing on the European context.

The second pillar comprises effective national and/or regional food composition programmes 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. Many developed 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 (EuroFIR, 2010 c; Schlotke and Moeller, 2000). On the other hand, in most developing and some developed countries, tables were produced within projects or as a private initiative, i.e. not within an institutional framework, and are not maintained over time. Therefore, many developing countries either do not have a food composition table or have one, which is many years old, out-of-date and contains inadequate data (INFOODS, 2010a). The political and institutional dimension of food composition programmes is outside the scope of this thesis. However, without this framework and sufficient resources allocated, food composition programmes and databases will not be developed and/or may not be sustainable over time (Greenfield and Southgate, 2003).

The third pillar is the training of professionals and students, in the different aspects of food composition. From 1992 to 2009, twenty-one international classroom-based postgraduate training courses on the production and management of food composition data were offered, mainly organized by the University of Wageningen (the Netherlands), the University of Pretoria (South Africa), the Graduate School VLAG (Advanced Studies in Food Technology, Agrobiotechnology, Nutrition and Health Sciences, the Netherlands), and the National Institute of Nutrition (NIN) in Hyderabad (India), mostly in collaboration with other organizations such as United Nations University (UNU), FAO, COST Action 99/ EUROFOODS, International Union of Nutritional Sciences (IUNS), or EuroFIR (INFOODS, 2010 b). These food composition courses essentially consist of lectures, which are complemented by group work, practical sessions and field trips. Each of these 21 courses covered all relevant aspects of food composition and was mainly taught by international lecturers. The two to three-week courses were each attended by 15-30 professionals involved in the generation, compilation and use of food composition data. Such international postgraduate courses are expensive, do not always train the most appropriate professionals and they were not always able to absorb the entire course content during the training or to contribute to institutional capacity development after return. In addition, potential sponsors of fellowships decreased their investment in food composition despite its recognized importance (Charrondiere *et al.,* 2009 c). Altogether, about 550 professionals were trained contributing to the development of capacity in food composition around the globe (INFOODS, 2010 b). However based on personal knowledge, it was found that a good number of them are not working any longer in the area of food composition due to e.g. job opportunities or retirement.

The demand for adequate knowledge and skills in food composition far exceeds the current supply provided through these international courses (Schoenfeldt, 2002; Hollman *et al.,* 2009). Especially in developing countries, there are still many professionals lacking the required knowledge and skills and who need to be trained in food composition in a more cost-effective manner. Such training could be offered through distance-learning courses and by incorporating food composition into the curricula of future professionals. Global access to the Internet and the widespread use of computers, including in developing countries (IBRD/WB, 2008), makes it nowadays feasible to train individuals in institutions through distance or e-learning. Distance learning is a formalized teaching and learning system specifically designed to be carried out remotely by using electronic communication through correspondence or television courses, CD ROMs, printed material, and the Internet. It can also be combined with classroom instruction. Distance learning is often used as a synonym for e-learning but e-learning is restricted to acquiring knowledge using electronic means (Rosenberg, 2001). Distance learning and e-learning are increasingly used in training professionals (Rosenberg, 2001; Codex Alimenatrius, 2005; FAO, 2010 a; Learning Center, 2010;) and in formal training, especially in natural science including nutrition, in high schools and universities (e.g. University of Bridgeport, 2010). Recently, e-learning modules or courses on analytical methods for food components also became available (EuroFIR, 2010 b, Open University, 2010).

FAO and INFOODS decided in 2006 to develop a distance-learning tool because no comprehensive distance, e-learning or on-line training was publicly available covering all aspects of food composition, and because the demand for well-trained professionals in food composition by far exceeds the supply through the existing lecture-based postgraduate training courses. This distance-learning tool was expected to contribute to filling the existing global knowledge and skills gaps in food composition by reaching a wide range of learners in different settings cost-effectively and by allowing them to acquire the knowledge and skills they need using a learning approach which actively involves learners and can be customized to their needs.

2. Objectives

The development and field testing of the 'Food Composition Study Guide' (Charrondiere *et al.,* 2009 a, b), which is a learning tool translating the comprehensive knowledge on food composition into questions, exercises and answers, is the main product of the doctorate studies undertaken by the author. In this document, the Food Composition Study Guide will be referred to as the Study Guide. After almost three years of work of the author in collaboration with colleagues at FAO, other food composition experts and Professor Elmadfa, the distance-leaning tool 'Food Composition Study Guide' was published in 2009 as a FAO publication. The entire work was financed by FAO.

The Food Composition Study Guide was developed to reach the following objectives:

(1) to make high-quality and standardized knowledge on food composition globally accessible to a wide audience at no or low cost, especially to students and professionals in developing countries;
(2) to allow learners to structure their acquisition of knowledge and skills on food composition;
(3) to allow learners to assess their acquisition of knowledge and skills and identify their remaining knowledge gaps through self-rating;
(4) to stimulate learners to fill their specific knowledge gaps on food composition;
(5) to inspire self-confidence in successful learners on their ability to apply the newly-acquired knowledge and skills in their jobs;
(6) to provide participants of classroom-based food composition courses with a tool to develop or deepen their knowledge and skills before or during a course, or to repeat topics from the course after its completion; and
(7) to assist universities and higher education institutes in updating their curricula for food composition and in providing courses on food composition to their students.

The actual thesis represents only a brief summary of the content of the five publications around the Study Guide while describing and discussing the objectives, the development, field testing and use of the Study Guide in more detail. The five publications are found in the *annexes*:

- the published article on the development of the Study Guide and its comparison to existing classroom-based food composition: Charrondiere, U.R., Burlingame, B., Berman S, Elmadfa I. (2009 c). Food composition training: Distance learning as a new approach and comparison to courses in the classroom. Journal of Food Composition and Analysis 22 (5), 421–432 (see annex 3);
- the submitted article on the use of the Study Guide: Charrondiere, U.R., Freisling, H, Elmadfa, I. (2010) The distance-learning tool 'Food Composition Study Guide' contributes to global capacity development in food composition (see annex 4);
- the submitted article on the Compilation Tool, a simple food composition database management system in Excel, which needed to be developed for learners to exercise data calculation, compilation and documentation when using the Study Guide: Charrondiere, U.R. & Burlingame, B. (2010) Report on the FAO/INFOODS Compilation Tool: a simple system to manage food composition data (see annex 5);
- Food Composition Study Guide "Questions and exercises – Volume 1" (Charrondiere *et al.*, 2009 a). In view of the huge number of pages of the two volumes of the Study Guide and the fact that all information of this volume is found in "Answers to questions and exercises – Volume 2" it was decided to include only module 1 of this volume (see annex 6). The entire publication is available at: http://www.fao.org/infoods/publications_en.stm; and
- Food Composition Study Guide "Answers to questions and exercises – Volume 2" (Charrondiere *et al.*, 2009 b) (see annex 7). The publication is available at: http://www.fao.org/infoods/publications_en.stm .

3. Development of the Food Composition Study Guide

(See corresponding published article by Charrondiere *et al.*, 2009 c in *Annex 3*)

The author's teaching experiences in several international food composition courses were used in the development of the Study Guide. One of the lessons learned was that participants always appreciated being asked questions during lectures, which seemed to stimulate their motivation to listen and assisted them to assimilate the new knowledge. Group work and exercises (e.g. to calculate or evaluate data) were also always highly valued by participants (EuroFIR, 2007; NIN, 2006 and 2007) because they were able to apply and test their knowledge.

A second lesson learned was that the lecture approach of the existing postgraduate courses is not always efficient and that another learning method and tools are needed to allow learners to more effectively acquire specific knowledge and skills in food composition, and if possible in their working language. It was observed that those participants of the above-mentioned postgraduate courses seemed to learn most effectively who already were working with food composition data because they could relate new knowledge to existing knowledge and experience and therefore assimilate the new concepts and information more easily, and appreciate how different parts are interrelated and influence the overall quality of food composition data and their applications (e.g. nutrient intake assessment). On the other hand, students with little or no previous knowledge of food composition had difficulty in assimilating the huge amount of new knowledge conveyed during courses, including essential knowledge. Participants stated that there was too much new information, that the new knowledge was not applied, that the speed of the course was too fast, or that due to language problems they had difficulty in following the lectures. Some students attended a course twice and recognized that they understood some issues only the second time.

The third lesson was that the application of the new knowledge is a key element to deepen the understanding of the issues learned. This experience was reinforced by the fact that for a complete learning experience the acquisition of knowledge and skills are equally important and that they complement each other (Mihai, 2009).

Therefore, for the development of the Study Guide, the concept of 'learning-by-doing' or 'active learning' was considered very appealing which has been successfully used in other fields (Michael, 2006). Thus, the possibility was considered to translate the whole course content of postgraduate courses into questions and exercises. In addition, emphasis was given to the acquisition of knowledge *and* skills, i.e. learners should acquire theoretical knowledge and should be able to apply it.

The different steps in the development of the Study Guide are described in Figure 1 and in the article Charrondiere *et al.* (2009 c), while additional background information is given in the text below.

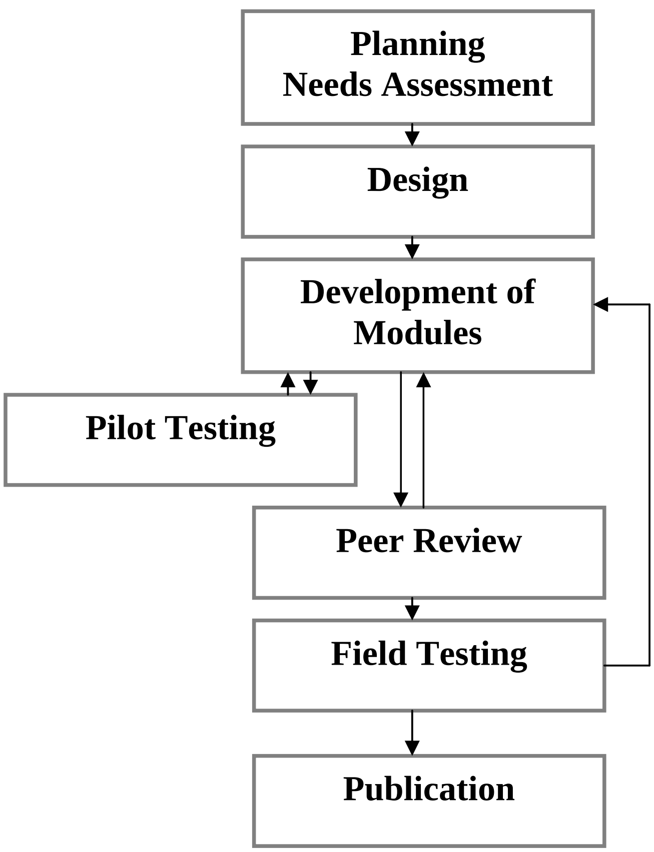

Figure 1 Steps in the development of the Food Composition Study Guide

Planning and needs assessment

This phase represents the research of the best approach to develop an efficient learning tool.

The first step in the planning process was a brief needs assessment among potential users through the INFOODS network. It revealed that many professionals, especially in developing countries, have important knowledge gaps in food composition and that the need for a distance-learning tool on food composition truly exists.

In the second step, potential partners and different forms and formats of existing distance and e-learning tools and learning theories were evaluated for the design of the Study Guide. Based on the needs assessment and the evaluation of existing material, it was decided to develop the Study Guide by using the principles of instructional design (Morrison *et al.,* 2004; Smith and Ragan, 1999).

The principles of instructional design were found useful as they represent a systematic and reflective process to design instruction. The application of instructional design is important for all media of instruction, while being critical for non-teaching based instruction. Its major premise is that the majority of students learn well and that instruction should not only be functional but also be attractive, inspiring and memorable to the end-users.

Instructional design involves an instructional analysis that investigates the profile of the learner (e.g. previous skills, motivation, time available, location, and means of assessing information) and the tasks they should be able to carry out. Based on this analysis it is possible to develop an instructional strategy, including selecting content, means, size and sequence of units, and the media. The last step in the instructional design is the evaluation of the instruction and the testing with learners if it was effective. The results should be used to revise the instruction (Smith and Ragan, 2005).

Instructional design is based on learning theories, which were influenced by Bloom's taxonomy of educational objectives (Bloom *et al.,* 1956). The objectives can be separated into cognitive, psychometric and affective domains. Psychometric abilities consist in the physical possibilities of the learners, which are important for learning of children or learning involving physical activities. The affective side of learning has the objective to increase interest and motivation, and to change values or attitude of the learner towards the learning content. The cognitive domain includes activities such as thinking, recalling knowledge, remembering, problem solving or creating. For adult learning in a scientific field such as food composition, the cognitive learning principles are the most relevant, while the psychometric and affective domains are less relevant.

Cognitive learning principles explain how knowledge is recognized, stored and retrieved by learners. According to Bloom (Bloom *et al.,* 1956), effective learning can only be achieved when the instruction addresses all six intellectual levels and not only knowledge acquisition as many instructions do. Knowledge is considered as the lowest cognitive level (i.e. a simple recall of information) followed by five increasingly higher intellectual levels such as comprehension, application, analysis, synthesis, and evaluation. Learners are able to understand and retrieve knowledge, if it was previously transferred from the working (or short-term) memory to the long-term memory, which is facilitated if:

- the information is meaningful and relevant to the learner;
- the teaching material and delivery of the content are of high quality and includes repetitions;
- learners participate in the learning process;
- learners apply the knowledge;
- the information can be related to prior knowledge;
- learners receive feedback e.g. from teachers, peers or in writing; and
- learners are interested, motivated and have a positive attitude (being personal attributes they are difficult to change but can be positively influenced if the above points are adequately addressed).

Combining instructional design, cognitive learning principles and the technical knowledge of food composition, should therefore enable the delivery of a high-quality and result-oriented learning tool. In the following, the creation of the Study Guide is described by following the steps as proposed by instructional design: design, development, implementation and evaluation.

Design

The first step in the instructional design was to define the objectives of the Study Guide (see above section on Objectives) and to carry out an instructional analysis (see **Table 1**).

Table 1 Instructional design of the Food Composition Study Guide

<table>
<tr><th>Elements</th><th>Compilers</th><th>Analysts</th><th>Users</th></tr>
<tr><td colspan="4">I. Define goals (see objectives) and perform instructional analysis</td></tr>
<tr><td rowspan="2">Profile of potential learners</td><td>• National and regional compilers
• Researchers and others compiling special-purpose food composition databases</td><td>Involved in food composition data generation, e.g. chemists</td><td>• Dietitians and other professionals using nutrient intakes and contents for different purposes
• Researchers in need of food composition data and their metadata to evaluate comparability
• Universities and higher education institutes
• Food industry
• Agricultural and health sector</td></tr>
<tr><td colspan="3"><u>Characteristics of users, analysts and compilers</u>:
• Higher educational background: students, professionals with higher education
• Fluent in English, French or Spanish
• Mainly from developing countries, but also from developed countries
• Working in institutes, government organizations, laboratories, etc.
• Various levels of previous knowledge of food composition
• Knowledgeable in the use of computers and internet
• Some will have experience with distance learning, others will not
• Unknown ability to work autonomously but it is assumed that people with previous on-line experience are more likely to succeed in working autonomously (Wojciechowski and Palmer, 2005)</td></tr>
<tr><td>Tasks they should be able to perform</td><td>• Coordinate and manage food composition programmes
• Integrate user's needs
• Elaborate sampling plans
• Coordinate data generation through analysis
• Compile and update FCDBs including building a food list and selecting nutrient
• Disseminate user FCDBs</td><td>• Elaborate sampling plan
• Prepare, manage and stock samples properly
• High-quality data generation using adequate and up-to-date analytical methods
• Deliver compositional data together with their meta data</td><td>• Identify correct match between foods consumed and foods in FCDBs
• Distinguish between different nutrient expressions and their influence on nutrient intake estimations
• Calculate high-quality nutrient values and intakes
• Apply food composition data adequately</td></tr>
</table>

(Table 1 continued)

Elements	Compilers	Analysts	Users
Needed knowledge	• On foods and components • How to coordinate and manage a food composition programme • Sampling principles and techniques • Principles and quality of analytical methods • Quality assessment of data in databases • How to select most adequate data and data sources • Compilation techniques (recipe calculation, documentation) and programmes	• On foods and components • Detailed knowledge on analytical methods and their quality assurance schemes (this cannot be provided through this tool – only principles) • Sampling principles and techniques • Data documentation	• On foods and components • Prevention of errors when using food composition data • Compilation techniques (recipe calculation, documentation) and programmes • Data quality assessment
Needs assessment	• Based on needs expressed in courses and by potential users		
II. Define instructional strategy and medium			
Strategy and medium	• Distance-learning tool (similar to correspondence course) comprising reading of specific literature and testing of acquired knowledge through questions (multiple choice, true/false, matching, open answer) and exercises (calculation, judgment, interpretation, organization). Achieved points will be used for self-rating. • To be used as stand-alone tool or in conjunction with courses • To be disseminated through internet, CD ROM, printed publication • Active publicity needed through FAO, IUNS and other channels • Online test and interactive course foreseen in the future, depending on availability of funds		
Special concerns	• Not all learners are fluent in English (therefore translation into French and Spanish) • Low level or drop of interest and motivation (therefore interesting questions and exercises which are easy to complete and to self-rate; and if possible add on-line test with certification)		
III. Evaluation			
Evaluation	• Pilot testing by professionals working with food composition data • Peer review of all modules • Field testing in conjunction with classroom-based courses, as a distance-learning course and with self-learners		
Revision	• Done after each testing • Updating of reference materials after first publication as they become available • For revised edition, addition of PowerPoint presentations summarizing the content of the required reading material (decrease time for reading)		

FCDB = food composition database
Source: Modified from Charrondiere *et al.,* 2009 c

This analysis showed that the Study Guide should be designed to meet the needs of the three types of potential users: compilers of food composition databases, users of food composition data and food analysts. They need the knowledge to generate, compile or use food composition data and should be able to apply it in their work. For each of these learner categories, specific tasks were identified and the corresponding knowledge needs were identified. Regarding the methods for food analysis, the Study Guide only covers their principles because they are important for data quality. The comprehensive knowledge in food chemistry is beyond the scope of the Study Guide and interested learners in analytical methods are invited to consult other sources referred to in the Study Guide.

It was decided to initially publish the Study Guide in the three main languages of the United Nations (i.e. English, French and Spanish) to allow a good number of users to work in their mother tongue or working language.

Existing food composition documents and courses were evaluated for their content (Charrondiere *et al.,* 2009 c) and relevant aspects on food composition were extracted for the Study Guide. It was found that 'Food composition data – production, management and use' (Greenfield and Southgate, 2003) covers most of the relevant topics and was, therefore, used as the main source of information for the Study Guide. This was complemented with additional information from other publications such as Klensin *et al*. (1989), Rand *et al.* (1991), Klensin (1992), FAO (2003, 2004, 2008), and EuroFIR documents (2010 a). In this way, all relevant topics of food composition are covered including emerging issues. The listed documents in the Study Guide represent the actual state of the art and, therefore, students will be exposed to the existing schools of thought with their different concepts and arguments.

Food composition aspects of food biodiversity were added to the Study Guide because it is an emerging topic for food composition and because its importance for nutrition and health is increasingly recognized which led to the development of the Nutritional Indicators for Biodiversity (FAO, 2008 and 2010 b). The consumption of different varieties and breeds within a species may have a significant impact on nutritional adequacy, as considerable differences in nutrient composition have been found among varieties of the same food. These studies showed that the intake of one rather than another could signify the difference between nutrient deficiency and adequacy (Burlingame *et al.*, 2009) and that diets rich in traditional foods including wild foods can have a significant impact on nutritional and health status (Kuhnlein *et al*., 2009). In order to demonstrate the positive impact of food biodiversity on nutrient adequacy and health, more and better data on food composition and consumption data below species level need to be collected and compiled. In order to make food composition compilers and users aware of the importance of food biodiversity in general and of composition

data below species level specifically, a module on food biodiversity was added to the Study Guide, hoping that in the future more national food composition databases and tables will contain these data and that more users will ask for these data.
Initially, the Study Guide contained 15 modules but the module on compilation became so big that it was decided to split it into three. Therefore, the current version of the Study Guide contains 17 modules. The modules divide the whole content of a course into smaller units. In this way, learners can easily choose the topic(s) they are interested in and thus gradually build up their knowledge. They also can repeat any module as often as necessary and spend as much time as needed per module. In this way, they can better assimilate the content of each unit.

The Study Guide was designed as a workbook consisting of two volumes: one containing 'Questions and exercises' and a second one 'Answers to questions and exercises' providing answers and feedback for self-scoring. In this way, it separates the completion of the questions and exercises from checking the answers and the self-scoring. It is expected that the maximum learning experience will be achieved when learners complete all questions and exercises before checking the corresponding answers.

Each of the 17 modules is separated into questions and exercises**. Table 2** lists the titles of the 17 modules and their relevance to the three main learner groups. Each module represents a small unit of the knowledge on food composition and is presented in the same way: (1) listing of the learning objectives, the reading and exercise material, and the estimated time to complete the module, (2) questions, and (3) exercises. Some optional questions were added for those with previous experience and knowledge or for those who had attended a food composition course.

Volume 2 'Answers to questions and exercises' provides the answers to the questions and exercises, explains why certain answers are right or wrong, indicates the number of scoring points and the page numbers of the source where the correct answer can be found. It also provides additional information on specific topics. In the last section, general feedback is given based on the scores achieved. In general, the maximum achievable points of the non-optional questions are divided into four categories, while the points from the optional questions are added to the highest quartile. The lowest quartile (0-25 % of points) is considered as an acquisition of knowledge and skills with major gaps, the second quartile with important gaps, the third quartile as a good acquisition of knowledge and skills, while the highest quartile (75-100 % of points) indicates an excellent acquisition of knowledge and skills.

Table 2 List of modules with their expected relevance to the three main learner groups on a scale of up to 5 points

Number of module	Name of module	Relevant for compilers	Relevant for professional data users*	Relevant for analysts
1	Basic principles of a food composition programme	●●●●●	●●●●●	●●
2	Use of food composition data	●●●●●	●●●●●	●●
3	Selection and nomenclature of foods in food composition databases	●●●●●	●●●●●	●●
4.a	Component selection	●●●●●	●●●●●	●
4.b	Component nomenclature	●●●●●	●●●●●	●●●●●
4.c	Component conventions and units	●●●●●	●●●●●	●●●●●
4.d	Methods of analysing components	●●	●●	●●●●●
5	Sampling	●●●●●	●	●●●●●
6	Quality aspects of analytical data	●●	●●	●●●●●
7	Resources for food composition Publishing food composition data	●●●●●	●●●●●	●●●●●
8	Recipe and other calculations	●●●●●	●●●●●	●
9	Food composition database management systems and data interchange	●●●●●	●●●●●	●
10	Compilation and documentation	●●●●●	●●●●●	●●●●●
10.a	Comparing food composition databases	●●●●●	●●●●●	●
10.b	Case study - translating food intake to nutrient intake	●●●●●	●●●●●	●
11	Quality considerations in data compilation	●●●●●	●●●●●	●●
12	Food biodiversity	●●●●	●●●●●	●●●●●

* A professional data user will utilize food composition data (e.g. to estimate nutrient intake, to produce labels, or to develop diets) and might compile purpose-driven food composition databases. They are unlikely to sample foods or supervise the analysis of foods.

Source: Charrondiere *et al.*, 2009 a

Development of the modules

The questions and exercises were constructed by addressing cognitive learning principles and the six levels of Bloom's taxonomy of cognitive objectives (Bloom *et al.*, 1956).

Cognitive learning principles were addressed in the Study Guide by:

- including relevant and authoritative documents on food composition;
- formulating questions and exercises which are relevant to the different topics and which represent real life situations;
- incorporating repetitions and views of the same content from different angles;
- asking the active participation of the learner (answering questions and completing exercises corresponding to 'learning-by-doing');
- asking learners to apply their new knowledge in exercises;
- gradually building up the knowledge within and between modules; and
- providing feedback to learners by giving them the right answers together with additional information and through the obtained points allowing them to assess their achievements.

Bloom (2010) suggests using for each of the cognitive levels (knowledge, comprehension, application, analysis, synthesis and evaluation) a number of verbs to formulate questions and tasks for learners (see **Table 3**). This terminology was extensively used in the formulation of the questions and exercises of the Study Guide and care was taken to address the six cognitive levels of Bloom's taxonomy. Thirty-five percent of the questions and exercises address knowledge on food composition and food biodiversity, 15 percent address comprehension, 30 percent application, 10 percent analysis, 8 percent synthesis, and 2 percent of the questions and exercises ask the learners to evaluate an issue (Charrondiere *et al.*, 2009 c).

Table 3 Bloom's taxonomy of cognitive objectives and their related verbs

Level of cognitive domains	Description	Corresponding verbs
1. Knowledge	Recall a specific information.	Define, duplicate, label, list, match, memorize, name, order, relate, repeat
2. Comprehension	Lowest level of understanding. Interpret information in own words.	Classify, describe, discuss, explain, express, identify, indicate, report, review, select, sort, translate
3. Application	Application of a rule or principle. Use knowledge or generalization in a new situation.	Apply, choose, demonstrate, employ, illustrate, interpret, operate, practice, prepare, schedule, solve, use
4. Analysis	Breaking down knowledge or an idea into parts and describing the relationships among parts. This involves a consideration of the material's form and its content.	Analyse, appraise, calculate, categorize, compare, criticize, diagram, differentiate, examine, question, test
5. Synthesis	Creatively or divergently applying prior knowledge and skills to produce a new or original whole and build relationships for the new situation.	Arrange, assemble, collect, compose, construct, create, design, formulate, manage, organize, plan, propose, set up, synthesize, write, develop, organize
6. Evaluation	Making judgement about material and methods based on given criteria which may lead to an action or product.	Appraise, argue, assess, attack, defend, estimate, evaluate, judge, predict, rate, score, support, value

Source: Adapted from Morrison *et al.,* 2004

The Study Guide contains mainly multiple-choice questions and few open questions, even though multiple-choice questions require less comprehension of the content because responses of students are guided by the predefined answers (Morrison *et al.,* 2004; Smith and Ragan, 1999). Multiple-choice questions were chosen because of the complexity of the content and the need for a simple and easy completion and self-scoring without ambiguity. Especially learners who are less familiar with English, French or Spanish would have more difficulty in formulating the answers to open questions. The language was kept simple and clear, and questions and exercises focus on essential notions and avoid the over-use of technical terminology.

The modules were structured in such a way as to allow students to first become familiar with the basic terms before increasing their knowledge (e.g. list, match) and comprehension (e.g. select, rank) of different principles and concepts, and of their appreciation of their importance for data quality.

The exercises enable learners to use the new knowledge in different contexts, e.g. to search for information on the internet or in reference material; to calculate nutrient intakes, recipes or values; to assemble a budget; to complete missing values; to compile values with data documentation; to rate actions or to argue about the inclusion or exclusion of data.

Evaluation through pilot testing and peer review

The third step in the instructional design was to develop and conduct an evaluation to assess the Study Guide (Smith and Ragan, 1999).

As a first step, the first five modules were **pilot tested** by five professionals already working in food composition. The objective of the pilot testing was to evaluate the usefulness of a distance-learning tool for food composition and to assess if the content and structure of the Study would be suitable for the acquisition of knowledge and skills for new and advanced learners. The pilot testers completed a module and a questionnaire. In general, they found that the modules were useful for gaining or refreshing knowledge and understanding, that they were well-structured and adequate for the purpose, even though at times difficult to complete. They also suggested improvements on wording. After this reassurance of the usefulness of the Study Guide, its structure and content, the existing modules were improved and the remaining modules were developed.

Thereafter, each module was evaluated by two to four **peer reviewers** for comprehensiveness, accuracy, coverage of relevant topics and for relevance to different user groups. The reviewers were experts in the topic covered by the module they evaluated. Most reviewers found the modules to be of high quality and comprehensive and suggested specific improvements of the text and content. The suggested improvements were incorporated into the modules, and when appropriate, sent back to the reviewer if changes were substantial.

The positive evaluation of the modules by the 36 pilot testers and the peer reviewers (see table 4) ensured that the content of the Study Guide presents up-to-date knowledge, is scientifically correct and comprehensive and can be understood by learners. The next phase consisted of testing the Study Guide in different settings.

4. Field testing and application of the Food Composition Study Guide

(See *Annex 4* for the corresponding article Charrondiere *et al.,* (2010) submitted to the Journal of Food Composition and Analysis)

Users of the Study Guide were advised to first read the indicated material or to follow a lecture on the topic, and then to answer the questions and exercises without looking at the answers. Scoring points were obtained for each correct answer, with which the final score was calculated. With the final score, learners could assess themselves through the feedback provided in the section 'General feedback using self-scoring'.

The Study Guide was successfully tested by 44 participants of three classroom-based food composition courses held in Iran, Benin and Ghana, 22 students at the University of Vienna in a classroom setting and as a distance-learning course, and by 7 self-learners at FAO Rome and the University of Pretoria in South Africa. The objectives of the field testing were to test the understanding of the questions and exercises by users and whether they were valuable in the different settings to achieve a good acquisition of knowledge and skills. After each testing event, the suggested improvements by users were incorporated into the next version of the Study Guide. **Table 4** describes the different applications of the Study Guide in terms of settings, specific objectives in the setting, participants, language, modules used, ways of using the modules, assessment of users, evaluation by users, and lessons learned.

Table 4 Comparison of different usages of the Study Guide in food composition courses, university settings and by self-learners and reviewers

	Food composition course in Iran (2008)	Course on food composition and biodiversity in Benin (2009)	Course on food composition and biodiversity in Ghana (2009)	University of Vienna as classroom course (2008)	University of Vienna as distance-learning course (2009)	Self-learners and reviewers working in food composition area (2007-9)	Self-learners with little or no previous knowledge in food composition (2009)
Setting	Food composition course of 2 weeks in classroom organized by FAO.	Course on food composition and biodiversity of 2 weeks in classroom organized by FAO and Bioversity International.	Course on food composition and biodiversity of 2 weeks in classroom organized by FAO and Bioversity International.	3 days block seminar in classroom: 'Correct use of food composition data', counting for 3 ECTS credits.	Self-learning plus 1 optional day in classroom: 'Correct use of food composition data', counting for 3 ECTS credits.	Pilot testing and peer review of modules by professionals working in food composition.	Volunteers, students or consultants to work with food composition data and/or on biodiversity (FAO, Rome; University of Pretoria, South Africa).
Specific objectives in the setting	To enable participants to generate, manage, compile and use food composition data correctly. To investigate understanding and quality of modules.	To enable participants to generate, manage, compile and use food composition data correctly. To investigate understanding and quality of modules.	To enable participants to generate, manage, compile and use food composition data correctly. To investigate understanding and quality of modules.	To enable participants to manage, compile and use food composition data correctly. To investigate understanding and quality of modules.	To enable participants to manage, compile and use food composition data correctly. To investigate understanding and quality of modules.	To investigate usefulness, understanding, completeness, quality and necessary improvements of modules.	To compile, calculate and use food composition data correctly and/or to work on biodiversity.
Participants	15 nutritionists, chemists and other health and nutrition specialists working in government agencies.	15 nutritionists, chemists and other health and nutrition specialists working in government agencies, NGOs, private sector and universities.	14 nutritionists, chemists and other health and nutrition specialists working in government agencies, NGOs, private sector and universities.	16 Master and doctorate students in nutrition of the University of Vienna.	6 Master and doctorate students in nutrition of the University of Vienna.	36 nutritionists, chemists and other health and nutrition specialists working in government agencies, private sector and universities.	5 nutritionists and 2 students.
Language	English	Course in French but modules in French and English	English	English	English	English	English
Answers available to users	No	No	No	No	Yes	Yes	Yes
Modules used	Modules 1-4.c and 5 by all participants. Modules 4.d and 6 only by chemists.	Modules 1-10, 12 out of which only modules 5, 6, 12 were in French.	Modules 1-10, 12.	Modules 4.a-4.c entirely. Part of module 2, 10.b.	Modules 1-3, 4.b, 4.c, 7, 8, 10, 11.	Each person evaluated one to three modules.	All modules, but mostly 4.b- 4.d, 8, 10, 12.

(Table 4 continued)

	Food composition course in Iran (2008)	Course on food composition and biodiversity in Benin (2009)	Course on food composition and biodiversity in Ghana (2009)	University of Vienna as classroom course (2008)	University of Vienna as distance-learning course (2009)	Self-learners and reviewers working in food composition area (2007-9)	Self-learners with little or no previous knowledge in food composition (2009)
Ways of using the modules	Participants completed the modules in 7 sessions after the corresponding lectures using handouts of the lectures and Greenfield and Southgate (2003). In an established order, each participant presented their answer to one question, which was then discussed by the whole group. Final test was a subset of questions from the modules used.	Participants received 10 modules 2 weeks before the course to complete them. Participants completed the modules in 8 sessions after the corresponding lectures using handouts of the lectures and Greenfield and Southgate (2003). In an established order, each participant presented the answer to one question, which was then discussed by the whole group. Final test was a subset of questions from the modules used.	Participants received 8 modules 4 weeks* before the course to complete them. Participants completed the modules in 8 sessions after the corresponding lectures using handouts of the lectures and Greenfield and Southgate (2003). In an established order, each participant presented the answer to one question, which was then discussed by the whole group. Final test was a subset of questions from the modules used.	Parts of the modules were used as exercises during the course, and modules 4.a-4.c were given as homework and answers were discussed the next morning. All lectures were immediately followed by a practical exercise, including from modules. Answers were not available to participants. Initial and final tests were a subset of questions from the modules used.	Students completed the modules alone (over 55 hours) and evaluated themselves. During the 1-day seminar, student's queries were clarified and a summary of important issues of each module was elaborated. Module 10.b was used to exercise food matching and compilation. Final test was a subset of questions from the modules used.	Each person completed the assigned module and gave feedback on understanding, completeness, and correctness, and provided suggestions for improvements.	Individuals completed modules, evaluated themselves and discussed with supervisor eventual questions. Then they compiled data, calculated recipes, worked on biodiversity, or used food composition data for their thesis.
Assessment of users' knowledge and skills acquisition	All participants passed the final test.	All participants passed the final test.	All participants passed the final test.	Very significant improvement (on average 2.8 marks) between initial and final test. All students passed, mostly with A and B marks.	All students passed with A and B marks.	Not applicable	They performed well the assigned tasks without much supervision time.
Evaluation/ comments by users	Useful to understand content of course but more time is needed.	Appreciated modules which generated discussions and allowed them to review and deepen knowledge from lectures, and to apply the new knowledge. Useful to evaluate remaining knowledge gaps. More time necessary for modules during the course. They should be sent 1 month before the course to participants. Modules should all be in French.	Study Guide was the backbone of the course. They stimulated discussion on the issues which helped understanding and comprehension. Appreciated the exercises which allowed them to apply the new knowledge. Useful to evaluate remaining knowledge gaps.	Heavy burden of homework but permitted to note that course content was understood.	Self-learning represented heavy burden. More time was needed than indicated, especially for exercises and reading (course material was in English and most students were German mother tongue). Students found the 1-day revision essential to digest and collate the acquired knowledge from the different modules. The usefulness of some modules was understood when completing the compilation module.	Provided suggestions for improvement and found in general that modules are comprehensive, well designed and systematic, and of high quality even though difficult for new learners. Reading material sometimes difficult to follow and to extract required information from them.	Useful to complete tasks. More time needed than indicated, especially for reading, and some questions and exercises were difficult. The usefulness of some modules was fully appreciated when compiling data. The biodiversity module gives a good overview on the topic. It was good to work in pairs as possible queries could be discussed.

(Table 4 continued)

	Food composition course in Iran (2008)	**Course on food composition and biodiversity in Benin (2009)**	**Course on food composition and biodiversity in Ghana (2009)**	**University of Vienna as classroom course (2008)**	**University of Vienna as distance-learning course (2009)**	**Self-learners and reviewers working in food composition area (2007-9)**	**Self-learners with little or no previous knowledge in food composition (2009)**
Lessons learned	Modules can successfully be used in conjunction with food composition courses. More time is needed for participants to complete the modules. It would be useful to send the modules to the students well before the course. Modules are useful for preparing lectures.	Students do not complete modules before the course. They should agree in writing to do so before the course. More time is needed for participants to complete the modules, if not done beforehand. Modules should be available in language of learners/course. Discussion of answers kept participants' attention and motivation high and allowed to comprehend course content.	Even though participants agreed to complete all modules, half of them completed 60-80% and the other half 10-40% before the course. It would be better to accept participants to the course only after passing an initial test, e.g. based on Study Guide. In general, those who completed the modules before the course profited well from the course and had better results in the final test. Modules allowed less experienced lecturers to run the course almost independently and to develop the final test.	Excellent course outline because each lecture is followed by a practical exercise, including from modules. Modules are useful in a university setting. They deepen the knowledge of the corresponding lecture. Modules give self-confidence. Students have excellent motivation and capacity to learn and apply. Course should be extended to 4 days and final test on day 5.	Modules can successfully be used as distance learning course in a university setting, especially if additional personal interaction/feed-back is provided. A one-day revision seems essential or a regular contact with students over e-mail or Internet. Non-English mother tongue learners need significantly more time to complete modules. Students spent significantly more time to acquire a deeper and larger understanding of food composition use and compilation as compared to a 3-days seminar.	Peer review and field testing are essential to obtain a good product. Suggested improvements were incorporated. Although most of the available reading material cannot be changed by FAO/INFOODS, some new ones could be developed in the future.	Effective means of knowledge transfer on food composition and food biodiversity. Study Guide summarizes and highlights main facts. Saves time for supervision and training. Profitable to work in pairs. More summarizing PowerPoint presentations were published on the INFOODS website and referred to in the Study Guide to reduce reading time.

* Two participants received the modules only few days before arrival because of late acceptance for the course.
ECTS = European Credit Transfer and Accumulation System
Source: Modified from Charrondiere *et al*., 2010

With professionals in conjunction with classroom food composition courses

All courses had 14 or 15 participants and were held in English, except for the course in Benin, which was held in French. The content of these courses was comparable with other postgraduate food composition courses, while the two African courses added several components on biodiversity. In all courses, participants answered the questions and completed the exercises individually or in groups with the help of the handouts of the lectures and information from the Greenfield and Southgate (2003) textbook. Participants did not have access to the answers. Thereafter, their answers were discussed with the whole group. Participants proposed some improvements to the modules, which were included in the next version. The final tests of the courses, which were subsets of questions from the Study Guide, showed that the participants well increased their knowledge and understanding in food composition. Participants reached 60-90 % of the points in the final test.

The FAO Regional Food Composition Course for the Near East and North Africa was held in 2008 in Teheran, Iran (INFOODS, 2010 a). It was the first course where the modules formed an integral part of the programme. Seven modules were partially or entirely tested by all participants (modules 1, 2, 3 and 4a, 4b, 4.c and 5) and modules 4.d and 6 only by those participants with laboratory experience. Most participants would have appreciated having more time to spend on the modules.

The first West Africa Graduate Course on Food Composition and Biodiversity was held in Cotonou, Benin, in 2009 and was organized by FAO and Bioversity International (INFOODS, 2010 a). It was the first food composition course ever held in French, even though all students were bilingual (French and English). The participants received 10 modules two weeks before the course and were asked to complete them before arriving at the course. As none of the participants had completed them beforehand, more time than foreseen was spent to complete them during the course. Only three modules were available in French, the others were in English.

The second West Africa Graduate Course on Food Composition and Biodiversity was held in Accra, Ghana, in 2009 and was organized by FAO and Bioversity International

(INFOODS, 2010 a). The participants received eight modules one month before the course and agreed to complete them before coming to the course. Half of the participants had completed 60-80% of the modules before the course and the other half 10-40%. Due to unforeseen circumstances, the two main international lecturers were not able or only partially able to attend the course. Many of the lectures were, therefore, given by local lecturers. Participants, together with the local lectures and the organizer from Bioversity International, who had also attended the course in Benin, went through the modules. Participants felt that the modules including the practical hands-on exercises were the backbone of the course. This course showed that less experienced lecturers are well-supported by the modules, through which they could conduct a high-quality food composition course and assess students.

With students in a university setting

At the University of Vienna, Austria, a three-day classroom-based seminar "Correct use of food composition tables" was held in 2008 in English by H. Freisling and the author, and 16 master and doctorate students attended the course. It consisted of 8 hours of lectures including discussion, 9 hours of exercises, 3-4 hours of homework and a 2-hour examination, counting for three ECTS credits (European Credit Transfer and Accumulation System). Emphasis was placed on food and component nomenclature and selection, food matching and the compilation of a simple food composition database including recipe calculation. Sampling, analytical methods and other quality aspects were covered only briefly to allow students to appreciate their influence on the nutrient values and the data quality. Every lecture was followed immediately by a practical and/or theoretical exercise to deepen the newly-acquired knowledge and to learn how to deal with difficulties when applying the new knowledge in practice. The 28 foods from the Austrian food frequency questionnaire (FFQ) (Freisling *et al.,* 2009) were put into food groups, coded, and were disaggregated into more specific foods. The draft Austrian Nutrient Database OELS was used to identify foods to apply their nutrient values to the FFQ foods and to match components to those of the Compilation Tool (INFOODS, 2010 b). Students were confronted with real-life problems when using food composition data (e.g. missing documentation, difficulties in food matching, or compilation errors due to the wrong interpretation of food description or overlooking differences in units or definitions of components). The modules 4.a, 4.b and 4.c were given as homework and parts of modules 2 and 10.b were used as exercises in the classroom. Some improvements in wording were suggested which were incorporated into the modules. The course survey showed that the students appreciated the modules for the immediacy of the feedback they provided and because they demonstrated their high level of assimilation of the course content, even though they needed 3-4 hours to complete them as homework. Students increased their knowledge of food composition significantly between the initial and final test, corresponding to 2.8 grades on average (on a 1-4 scale).

At the University of Vienna, Austria, a distance-learning course "Correct use of food composition data" was held in 2009 in English, counting for three ECTS credits. It consisted of completing modules 1-3, 4.b, 4.c, 7, 8, 10, 11 (about 55 hours), and one optional day of face-to-face discussions with the instructor (the author). Out of the 11 students who registered, only 6 attended the course. During the one-day classroom discussion, queries were answered and the important issues of each module were elaborated. Some time was left to use module 10.b to apply food and component nomenclature, food selection and food matching using the USDA (2010 a) database Standard Release 22. There was not enough time left to compile the data. The students appreciated the one-day interaction, which increased their understanding significantly, but found that the reading and exercises took much more time than indicated and, at times, answering questions and completing exercises was difficult with the reading material made available. The achieved Grades (A and B grades) demonstrated that they understood well most issues of the modules.

With professionals as self-learners to carry out specific tasks

The Study Guide has been used by self-learners (five volunteers and consultants at FAO Rome) to obtain the knowledge and understanding to be able to carry out tasks on food composition and/or food biodiversity:

- to calculate nutrient values of recipes using different recipe calculation systems and retention factors with the Compilation Tool (Charrondiere and Burlingame, 2010);

- to collect relevant food composition data on food biodiversity from different sources and to compile them into a biodiversity food composition database using the Compilation Tool; and
- to develop the Nutrition Indicators for Biodiversity on food consumption (FAO, 2010) and to collect data for the indicator.

They completed modules 4.b, 4.c, 4.d, 8, 10, 12, which took them 5-12 hours for each module, and appreciated the value of certain modules (especially component nomenclature, conventions and units) only when compiling and calculating food composition data. The fact that new volunteers and consultants complete specific modules and evaluate themselves saves a lot of training and supervision time while assuring that they receive the comprehensive and standardized knowledge needed to fulfil the specific tasks they are assigned. Similar experience was gained when using the Study Guide at the University of Pretoria, South Africa, where students completed all modules to work with food composition data for their theses.

5. Publication of the Food Composition Study Guide

(See FAO publications Charrondiere *et al.*, 2009 a, b in *Annexes 6* and 7)

In September 2009, the two volumes of the Food Composition Study Guide were published in English as PDF files on the INFOODS website http://www.fao.org/infoods/publications_en.stm. They are in English and can be downloaded free of charge and their use is encouraged as widely as possible. The French and Spanish translations and the printed English version are expected to be available in the second half of 2010. It is also planned to provide CD ROMs with the modules and the listed reference materials for those learners with limited internet access.

In April 2010, a revised English edition was published including more recent references and additional PowerPoint presentations summarizing the content of the reading material so that learners will have to spend less time on reading. The need for permanent updating is one of the major challenges for e-learning modules (Mihai, 2009).

6. An additional tool to the Study Guide: the "Compilation Tool" to apply recipe calculations, and data compilation and documentation

(see *Annex 5* for the corresponding article Charrondiere and Burlingame (2010) submitted to be published in the Journal of Food Composition and Analysis)

For some of the exercises in the Study Guide, an instrument was needed to allow learners to practise recipe calculation, compilation and documentation. As no such tool was publicly available, the 'Compilation Tool' was developed by FAO/INFOODS (Charrondiere & Burlingame, 2010). The Compilation Tool is also intended to be used by compilers without a sophisticated food composition database management system to assemble, manage and publish their food composition databases. The Compilation Tool is the first food composition database management tool which is globally available and free of charge. It can be downloaded from the INFOODS website (2010 c), together with guidelines for its use.

It is an Excel spreadsheet and serves as a simple food composition database management system. It follows the structure according to Greenfield & Southgate (2003) and separates the archival, reference and user databases. It is based on the INFOODS standards for food composition data interchange (FAO, 2004) and on the INFOODS component identifiers (Klensin *et al.,* 1989; INFOODS, 2010 e). It should however be noted that it does not contain any food composition database. It allows users to compile and manage a food composition database according to INFOODS recommendations; to calculate nutrient values of recipes using any of the three calculation systems (the recipe method, ingredient method and mixed method) with any set of nutrient retention factors at food group level and any yield factors; and it allows data to be documented comprehensively through specific fields in 11 worksheets.

The Compilation Tool has been used in different settings, e.g. to compile a national food composition database or a food composition database for biodiversity, to investigate differences in recipe calculation systems and nutrient retention factors, or in conjunction with the Study Guide to practise data compilation, calculation and documentation.

7. Discussion

High-quality and standardized knowledge on food composition

The Study Guide was developed using instructional design, cognitive learning objectives and the theorem of 'learning-by-doing' or active learning to produce a well-structured and comprehensive distance-learning tool on food composition. Based on these theories and the author's experiences, the learning content was put into questions and exercises to enable learners to participate actively in the learning process. This learning approach is in line with other non-lecture based approaches such as peer education (Khan *et al.,* 2009) or interteaching (Goto and Schneider, 2009).

The questions summarize the important issues of the reading material, start with basic knowledge (definitions of basic terms, concepts and principles), and guide the students gradually to higher levels of understanding and comprehension. In order to allow an easy completion and self-scoring, most questions in the Study Guide are multiple-choice questions and only some are open questions. The exercises focus on skill acquisition, which assist learners to comprehend and apply the theoretical knowledge while pointing to areas which are prone to errors in their application (e.g. calculations or change of units). As students are eager to carry out exercises but less engaged in analyzing or interpreting them (Lee *et al.*, 2009), additional interpretation is provided in the section 'For your information' or through additional questions asking students to interpret the obtained results.

The division of the content into 17 modules allows learners to complete only those modules of interest to them and where they have specific knowledge gaps to be addressed. In addition, each module contains indications on the usefulness for compilers, users and analysts (see **Table 2**).

The quality of the Study Guide was assured through the application of instructional design and cognitive learning principles in its development and through a peer-review process. This process showed that the questions and exercises of the Study Guide are of a high standard and cover all relevant issues comprehensively and correctly, which was also demonstrated by the good comparison of the Study Guide's content with that of the postgraduate food composition courses. In addition, all information disseminated through the Study Guide is standardized (Charrondiere *et al.,* 2009 c).

Through the application of the principles of instructional design, the Study Guide fulfils most of the criteria of the quality assurance system for e-learning modules proposed by Mihai (2009). The quality assurance system is divided into the same phases as instructional design: planning, design, delivery and evaluation. In addition, Mihai (2009) proposes to use the following criteria to assess e-leaning modules: Knowledge and skills acquisition, flexibility, learning by association, case studies and real-life scenarios and interactive component. The Study Guide does not fully adhere to all criteria as it does not include an interactive format (it is a static document in two volumes although it includes hyperlinks to all referred documents), and because it takes 3 to 9 hours to complete one module which is incompatible with the criteria of a quick learning experience. In the Study Guide, priority was given to a full coverage of all important topics.

In addition, Baker (2003) proposes to use Bloom's taxonomy of cognitive objectives (Bloom *et al.,* 1956; Bloom, 2010) to assess the quality of learning and education of distance-learning courses. As the Study Guide addresses all six cognitive levels, it can be considered of high quality.

Application of the Study Guide in the field

The Study Guide was successfully tested and implemented in three classroom-based postgraduate food composition courses, in a university setting as part of a nutrition curriculum as seminar or distance-learning course, and by self-learners and reviewers (see **Table 4**). It was demonstrated that learners increased their knowledge significantly, i.e. 2.8 grades on average (on a 1-4 scale) between the initial and final test or by passing the final test with 60-90% of achievable points. Students in the university courses in general obtained better results than participants of postgraduate courses.

In general, users appreciated the modules because they helped them to:

- understand main facts on food composition while highlighting small but important details;

- review and thus better understand the content of the lectures;
- to share their experiences and views which generated lively discussions;
- keep their attention high even after many hours of course work;
- assess their acquired knowledge and skills while identifying remaining knowledge gaps; and
- gain confidence in their ability to apply the knowledge.

Often, they fully understood the importance of some modules (e.g. component nomenclature) only when using the new skills in, for instance, compiling of a food composition database or when completing module 10 “Compilation and documentation”. Some learners initially found those exercises less valuable, which consisted of looking up information in different resources, but appreciated them later on when realizing that they knew where to locate the needed information.

The revised editions of the Study Guide of 2010 should facilitate and improve the knowledge acquisition as compared to the editions published in 2009 because the section on ‘Required reading’ was enlarged with PowerPoint presentations summarizing the main issues of the reading material and with newly-available documents. These presentations, available on the INFOODS (2010 d) website, will not only shorten reading time for learners, but will further assist instructors to develop their teaching material for courses.

Learners can assess their acquisition of knowledge and skills

The evaluations, tests and oral feedback of users of the Study Guide proved that participants of food composition courses, students at universities and self-learners were able to assess their acquisition of theoretical and practical competences through self-scoring and general feedback, through the discussions of the answers with peers or instructors, and through the tests.

Most of the self-learners reported having obtained scores in the first or second quartile of possible points, equivalent to 75-100% or 50-74% of points, respectively. This means that the acquisition of knowledge and skills was good to excellent. They were also able to identify remaining knowledge gaps.

The Study Guide as a stand-alone distance-learning tool

Important factors for successful learning in general are quality of the instruction, feedback (e.g. from teacher or peers), interest and motivation (Smith and Ragan, 1999; Rosenberg, 2001). Also for on-line courses Herbert (2006) found that responsiveness by the faculty and the quality of the instruction were important for learner satisfaction. However, no specific factors could be identified explaining the drop-out of students from courses. Wojciechowski and Palmer (2005) found that those students of on-line courses had lower drop-out rates who had good rates, had attended an orientation session, had computer knowledge, had successfully completed other on-line courses and had the necessary independence and time management skills needed for persistence, and were between 30-50 years of age.

It is expected that learners in need of knowledge in food composition are highly motivated to complete the relevant modules. In addition, the Study Guide aims to achieve high-quality instruction and actively involves them in the learning process through answering questions and exercises. By verifying their answers, they receive feedback on their acquisition of knowledge and skills. It is expected that these elements are able to keep the motivation of learners high to continue completing all relevant modules.

Self-learners were able to acquire the necessary knowledge and skills to carry out tasks with food composition data and/or work on food biodiversity, even though at times they found the completion of the modules challenging (Charrondiere *et al.,* 2010). This is encouraging as it is known that distance-learning courses have high drop-out rates which makes the acquisition of knowledge and skills less effective (Herbert, 2006; Wojciechowski and Palmer, 2005). Even though the risk exists that self-learners will not fully complete all the relevant modules, the value of self-learning should not be underestimated, especially for those who will never have a chance to attend a food composition course. For this reason, it is expected that the Study Guide will be most useful in developing countries where demand for these knowledge and skills is high while the possibility of attending a food composition course is limited.

The decreasing motivation of self-learners in the completion of the modules could be further addressed by transforming the Study Guide into an interactive e-learning course with the possibility of obtaining a certificate of completion, even though cheating in online tests (Rowe, 2004) has to be considered and solved before offering such certification. Another possibility is to create learning groups, i.e. two or more learners complete the same module and discuss their answers among peers face-to-face, over the phone, Skype, e-mail, or other chatting mechanisms.

The Study Guide assists universities and higher education institutes in updating their curricula on food composition

The Study Guide is a useful tool to introduce food composition into the curricula of universities or other higher education institutes, either in a classroom setting or through distance learning. However, when distance-learning courses are offered to students, there should be one day of personal interaction between instructors and learners to discuss remaining difficulties and to carry out exercises under the supervision of the instructor. The personal interaction could also be carried out virtually by using modern telecommunication means such as Skype calls or video-conferences, where the instructors and learners are located at different places, provided connectivity at the learning location.

The courses given at the University of Vienna could be extended to other universities teaching nutrition or other subjects such as dietetics, food science, food chemistry, epidemiology and others. If this were to be done successfully, in the future, a wide range of professionals would have the relevant knowledge on food composition and would, therefore, be able to correctly generate, compile and use food composition data. A survey, conducted in 2009 by the author, showed that over 35 universities worldwide are interested in implementing the Study Guide to incorporate food composition topics into their curricula.

New learning approaches for classroom-based formal training through the Study Guide

It is also planned to test more approaches for postgraduate and university food composition courses (e.g. at University of Hebron, West Bank, Palestine) where the Study Guide will be used as a distance-learning tool, i.e. students complete all or selected modules of the Study Guide as a pre-requisite for the course. This will allow the classroom-based course to place more emphasis on activities at higher intellectual levels as described by Bloom (Bloom *et al.*, 1956), which could make the course more effective, interesting and result-oriented. This method could shorten the classroom courses and thus make them cheaper (Morrison *et al.*, 2004; Rosenberg, 2001). During these courses, trainers can be instructed in this new learning-style for future courses, where learners have access to a computer.

The Study Guide can assist instructors

The Study Guide was not only valuable to the participants, but also to instructors who were able, with the Study Guide, to organize a high-quality food composition course according to international standards and to better develop their lectures.

The Study Guide also permitted instructors to develop multiple-choice tests to assess the retained knowledge and comprehension of students. The tests were always a subset of the questions discussed during the course and all participants passed the test.

Reaching the target audience

The free-of-charge availability of the Study Guide in English, French and Spanish through the Internet and, in the future, through CD ROMs, makes it accessible to learners at any time and location.

In order to reach a wide audience, FAO, INFOODS and other organization (e.g. IUNS) plan to actively communicate the usefulness of the Study Guide to potential users, especially for self-learners, relevant institutes, ministries and universities. Three scientific articles were published or are submitted for publication on the development and use of Study Guide. In 2009, at the International Conference for Nutrition and the

8th International Food Data Conference, posters and presentations were given on the use of the Study Guide. A press release is planned, once it is printed. It has already been announced through newsletters (e.g. USDA, 2010 b), Codex (Codex 2010, USDA, 2010 c), mailing lists (e.g. INFOODS mailing list), websites of professional organizations (IDF, 2010) and organizations (OOAS, 2010).

Capacity development of institutes and countries

In the past, capacity building was solely concerned with technical knowledge transfer and training of individuals. Nowadays, we speak of ‘Capacity development’, which goes beyond technical knowledge and includes the environment where the capacity should be developed. Therefore, capacity development involves three inter-linked dimensions: individual, institutional/organisational, and policy/enabling environment. It was demonstrated that it is not sufficient to enhance the knowledge and skills of individuals in technical areas but that additional functional capacities are needed to make a change such as the ability in planning, collaborating, facilitation, communication or advocacy. Moreover, capacity development needs to be embedded in an institution/organization environment, which provides human and financial resources or infrastructure needed to develop the new capacity. Furthermore, the institution can only provide the necessary resources if the policy and enabling environment dimension permits them to do so through existing policies, legal and economic frameworks. Therefore, capacity development initiatives should be designed to maximise learning at each of the three levels of capacity development (OECD, 2006).

The learning and working environment is an important factor for the capacity development of institutions or organizations and can either be stimulating or obstructive (Rosenberg, 2001). Those learners already working in the area of food composition are most likely to use the newly gained knowledge and skills in their work, thus contributing most likely to the institutional capacity development. However, those learners not yet working in the area are only able to implement the newly acquired knowledge in their work if they obtain the support and resources from their supervisors and institutions and are able to integrate food composition into their work plans. Therefore, not all participants trained in food composition were able to apply their new skills in their work. However, a more detailed analysis of the influence of the learning and working environment for capacity development of institutions is outside the scope of this thesis.

The Study Guide will be able to contribute to the technical capacity building of individuals in the field of food composition. Other functional capacities have to be acquired through other means. The Study Guide is expected to be most efficient for users such as nutritionists, epidemiologists, dietitians, and professionals in agriculture, food trade and food industry (for labelling and product development). The Study Guide will increase the knowledge and skills of compilers but this new capacity will only lead to more published high-quality food composition tables and databases if more institutions are equipped with the mandate and the corresponding human and financial resources. However, the more professionals in governments are aware of the underlying tasks to develop an adequate, reliable and up-to-date food composition database and their importance for the quality of the resulting nutrient intake estimation, research and policies, the more likely it is that adequate food composition databases will be developed and maintained.

As food composition databases or tables are one of the fundamental tools in nutrition, the Study Guide, in combination with the Compilation Tool, might be able to contribute to a broader national capacity building in nutrition, especially in developing countries. The development and maintenance of a food composition table could develop the nutrition capacity of those institutes responsible for it, in most cases these will be national nutrition institutes. Many developing countries do not undertake food consumption surveys because they do not have a food composition table, but once they have a high-quality national food composition table (containing also local foods and recipes) they might carry out food consumption surveys, do more nutritional research, and other nutrition related activities. In addition, as Codex (2009) is discussing mandatory nutrition labelling, the demand for reliable food composition data will increase in the future. As this time, the demand for these data comes from trade and commerce it might be possible that more resources become available for food composition work, including chemical analysis of foods.

8. Conclusion

The Study Guide has proven to assist a wide range of self-learners and participants of university and postgraduate courses in their acquisition of knowledge and skills in food composition and food biodiversity. They were able to acquire the relevant knowledge to perform correctly tasks related to the topics, even though the completion of the Study Guide was at times challenging. The 'Food Composition Study Guide' will especially be useful in developing countries, where the demand for knowledge and skills on food composition and food biodiversity is high. With the Study Guide, standardized and comprehensive knowledge on food composition and food biodiversity can be shared globally at low cost for users, and learners can tailor their course according to their knowledge gaps and available study time. In addition, its translation into French and Spanish will allow more learners to acquire knowledge and skills in their own language.

The Study Guide and the related PowerPoint presentations are also useful for instructors of postgraduate or university courses to prepare lectures and to carry out high-quality courses on food composition and food biodiversity. Through active communication by e.g. FAO, IUNS, and Codex Alimentarius on its usefulness, it is expected that the Study Guide will be used widely and that more courses on food composition and food biodiversity will be offered to working professionals and in universities.

The combination of the Study Guide with the Compilation Tool does not only assist learners in the acquisition of knowledge and skills on food composition and food biodiversity, but will also help governments, institutes and the food industry to develop and publish high-quality food composition tables and databases at national or regional level, especially in developing countries. These tables and databases might then allow a further capacity development in nutrition through carrying out national food consumption surveys and nutritional research. They will also assist the food industry to calculate the nutrient content of their products and use them for nutrition labelling.

9. Summary

The '*Food Composition Study Guide*' was developed to fill a global knowledge gap in food composition and food biodiversity, especially in developing countries. It is a distance learning tool divided into 17 modules, covering all relevant topics on food composition and food biodiversity in the form of questions, exercises and answers. The main topics covered are basic principles and use of food composition data, food and component nomenclature, sampling, quality of data, compilation, documentation and calculation and food biodiversity. In 2009, the English version of the *Study Guide* was published electronically by FAO in two volumes and can be freely downloaded from http://www.fao.org/infoods/publications_en.stm.

The modules were based on the principles of instructional design, Bloom's taxonomy of cognitive objectives, the results of a need assessment, and on available authorative documents (mainly from FAO and INFOODS but also EuroFIR). The Study Guide was peer reviewed, pilot tested and successfully used in different settings: in conjunction with three international classroom-based food composition courses, in a university setting, and by self-learners. The implementation of the modules demonstrated that they represent a useful tool for teachers to prepare lectures or to run a complete course and for learners to acquire and deepen their knowledge and skills, being afterwards able to successfully carry out tasks related to food composition and food biodiversity.

The Study Guide permits to develop new innovative approaches to carry out food composition courses (i.e. more interactive and result-oriented) and to introduce food composition into the curricula of universities, e.g. as distance-learning courses, seminars, or simply in selected lectures. Over 35 universities around the world have already indicated their interest in using the Study Guide. It is expected that it will be widely used among the above mentioned potential user groups, which will be enhanced through its translation into French and Spanish. It is hoped that the Study Guide together with the simple food composition database management system "Compilation Tool", developed as an Excel file by FAO/INFOODS, will allow more developing countries to develop and publish a national food composition database including its food biodiversity.

10. Zusammenfassung

Der '*Food Composition Study Guide*' (Lernprogramm zur Lebensmittelzusammensetzung) wurde entwickelt, um eine globale, jedoch besonders in Entwicklungsländern bestehende Wissenslücke in Lebensmittelzusammensetzung zu füllen. Er ist ein Fernlehrmittel (distance learning tool), das in 17 Module unterteilt ist, und alle wichtigen Themen über die Zusammensetzung und Biodiversität von Lebensmitteln in Form von Fragen, Űbungen und Antworten abdeckt. Der *Study Guide* umfasst folgende Themen: Grundlagen und Verwendung von Daten über die Zusammenstzung von Lebensmitteln, Lebensmittel- und Komponentennomenklatur, Probenahme, Datenqualität, Kompilation, Dokumentation und Berechnung von Daten, und Lebensmittelbiodiversität. Die englische Version des *Study Guide* wurde 2009 in zwei Bänden als FAO Dokument veröffentlicht und kann kostenfrei von http://www.fao.org/infoods/publications_en.stm heruntergeladen werden.

Die Module wurden unter Anwendung der Prinzipien des Instruktionsdesign und Blooms Taxonomie der kognitiven Lernziele entwickelt und basieren auf Ergebnissen einer Bedarfserhebung, sowie wichtigen themen-relevanten Publikationen (hauptsächlich von der FAO, INFOODS, und EuroFIR). Der *Study Guide* wurde von Experten begutachtet und danach erfolgreich getested und angewandt: in drei internationalen Lehrgängen über die Lebensmittelzusammensetzung im Direktunterricht, im Rahmen der Universitätslehre sowie von Fachleuten im Selbststudium. Der Einsatz der Module zeigte, dass sie für Lehrer und Lernende nützlich sind: Lehrende können damit Unterrichtsmaterial erstellen und ganze Kurse geben, und Lernende können damit Wissen und Können gewinnen oder vertiefen und danach erfolgreich Aufgaben im Bereich der Zusammensetzung und Biodiversität von Lebensmitteln ausführen.

Mit dem *Study Guide* können neue und innovative Lehrgänge durchgeführt werden (z.B. interaktiv and ergebnisorientiert). Lebensmittelzusammensetzung kann dadurch in Universitäten vielseitig unterrichtet werden: als Fernlehrgang mit kurzem Direktunterricht, in Seminaren, oder einfach in Vorlesungen. Űber 35 Universitäten haben bereits Interesse gezeigt, den *Study Guide* in der Lehre anzuwenden. Die weite Anwendung des *Study Guide* sowohl in Lehrgängen und an Universitäten, als auch im

Selbststudium wird gefördert durch seine Űbersetzung ins Französische und Spanische. Es wird erwartet, dass der Gebrauch des *Study Guide* zusammen mit dem simplen Datenmanagementsystem “Compilation Tool“, das von der FAO/INFOODS in Excel entickelt wurde, in vielen Entwicklungsländern zu Veröffentlichung von nationalen Nährwerttabellen führt.

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Annex 1

Publications with author's contribution

Scientific articles and book chapters (in chronological order starting with most recent ones)

Charrondiere, U.R., Freisling, H, Elmadfa, I. (2010). The distance learning tool 'Food Composition Study Guide' contributes to global capacity development in food composition (submitted to *Journal of Food Composition and Analysis*)

Charrondiere, U.R. & Burlingame, B. (2010). Compilation Tool for food composition in Excel format for use in the absence of a food composition database management system (submitted for publication in the *Journal of Food Composition and Analysis*).

Charrondiere, U.R. (2010). Preparing a Total Diet Study Food List. In: Total Diet Studies. Moy, G.G., Vannoort, R., Verger, P. (Eds). *Springer, New York*. To be published in 2010.

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Stadlmayr, B., Nilson, E., Charrondiere, U.R., Medhammer, E., Mouille, B., Burlingame, B. (2010). Nutritional Indicator Biodiversity for Food Composition - A report on the progress of data availability (submitted to *Journal of Food Composition and Analysis*).

Charrondiere, U.R., Burlingame, B., Berman, S., Elmadfa, I. (2009). Food composition training: Distance learning as a new approach and comparison to courses in the classroom, *Journal of Food Composition and Analysis*, 22 (5), 421–432.

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Leclercq, C., Charrondiere, U.R., DiNovi, M., Baines, J., Leblanc, J.C., Verger, P., Renwick, A., Abbott, P., Sipes, G. (2009). Incorporation of the Single Portion Exposure Technique (SPET) into the Procedure for the safety evaluation of flavouring agents. In: *WHO food additives series*, 60, 267-289.

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Poster presentations (in chronological order starting with most recent ones)

Mouille, B., Charrondiere, U.R. &. Burlingame, B. (2009) Analysis on nutrient composition data on potato: identification of nutritionally interesting potato cultivars'. 8th International Food Data Conference, Bangkok, Thailand.

Charrondiere, U.R., Burlingame, B. & Elmadfa, I. (2009) Capacity building in food composition through distance learning. 19th International Congress on Nutrition, Bangkok, Thailand.

Mouille, B., Burlingame, B. &. Charrondiere, U.R. (2009) Analysis of nutrient composition data: potato as a source of compounds with antioxidant activities. 19th International Congress on Nutrition, Bangkok, Thailand.

Charrondiere, U.R., Burlingame, B. & Eyzaguirre, P. (2008) Nutrition Indicator for Biodiversity – 1. Food Composition. Thirteenth Meeting of the Subsidiary Body on Scientific, Technical, and Technological Advice, 18 to 22 February 2008, FAO Headquarters, Rome, Italy.

Charrondiere, U.R., Chevassus-Agnes, S., Marroni, S., Dop, M.C., Burlingame, B. (2003) How comparable are energy values globally? Impact of macronutrient definitions and energy conversion factors. Poster presentation. Proceeding of the 9th European Nutrition Conference, Rome, Italy, 1-4-October 2003 in *Annals of Nutrition and Metabolism.*

Charrondiere, U.R., Vignat, J. & Riboli, E. (2001) Differences in Fibre Intake of a British Cohort due to the Application of the British, Danish and French Food Composition Tables (FCT). In: Nutrition and Lifestyle: Opportunities for Cancer prevention. Eds. Riboli E and Lambert R. *IARC Scientific Publications No. 156*, 2002, 45-47.

Charrondiere, U.R., Vignat, J. & Riboli, E. (2001) Comparable Nutrient Intake across Countries is only possible through Standardization of Existing Food Composition Tables (FCT). In: Nutrition and Lifestyle: Opportunities for Cancer prevention. Eds. Riboli E and Lambert R. *IARC Scientific Publications No. 156*, 2002, 39-40.

Unwin, I.D., Vignat, J., & Charrondière, U.R. (2001) Software Support for EPIC Food Composition Data Preparation in the European Nutrient Database (ENDB) project. In: Proceedings of the 'European Conference on Nutrition and Cancer' Lyon, France, 21-24 June 2001.

Charrondiere, U.R., Vignat, J., Slimani, N., Riboli, E. (2001) How accurate can Nutrient Intake be estimated due to the Increasing Amount of Manufactured Foods in our Diets? Proceedings of the Fourth International Food Data Conference, Bratislava, Slovakia, 24-26 August 2001.

Vignat, J., Ireland, J., Møller, A., Unwin, I.D., Charrondière, U.R. (2001) Guideline Notes for Preparing and Exporting Food Composition Data According to the Common Formats of Export Files. Proceedings of the Fourth International Food Data Conference, Bratislava, Slovakia, 24-26 August 2001.

Oral presentations at conferences

Charrondiere, U.R., Sivieri, A. & Burlingame, B. (2009) Differences in nutrient values of recipes due to different calculation methods and sets of retention factors. 8th International Food Data Conference, Bangkok, Thailand.

Charrondiere, U.R., Burlingame, B., Berman, S., Freisling, H., Elmadfa, I. (2009) Capacity building in food composition through distance learning and formal education. 8th International Food Data Conference, Bangkok, Thailand.

Charrondiere, U.R. & Burlingame, B. (2009) Compilation tool for food composition in Excel for use in absence of a food composition database management system. 8th International Food Data Conference, Bangkok, Thailand.

Charrondiere, U.R. & Burlingame, B. (2009) Report of Food Composition courses 2008-2009. 8th International Food Data Conference, Bangkok, Thailand.

Charrondiere, U.R. & Burlingame, B. (2009) Biodiversity and food composition. 19th International Congress on Nutrition, Bangkok, Thailand.

Charrondiere, U.R. (2008) Indicator for Nutrient Composition. Side event of Thirteenth Meeting of the Subsidiary Body on Scientific, Technical, and Technological Advice, 18 to 22 February 2008, FAO Headquarters, Rome, Italy.

Charrondiere, U.R. & Burlingame, B. (2007) Training in food composition: A self-guided study workbook. 7th International Food Data Conference, Sao Paulo, Brazil.

Charrondiere, U.R. & Burlingame, B. (2007) FAO INFOODS - Training activities outside Europe. 2nd International EuroFIR Congress in Granada, Spain, 27-28 September 2007.

Charrondiere, U.R. (2006) Stratégie globale de l'OMS pour l'alimentation, l'exercice physique et la santé – application au niveau national et liens avec les travaux du Codex. General Assembly of Maison du Lait, Paris, 27-28 June 2006.

Charrondiere, U.R. & Burlingame, B. (2005) Revision of INFOODS tagnames and comparison with other component identification systems. 6th International Food Data Conference, Pretoria, South Africa.

Burlingame, B., Charrondiere, U.R., N'Diaye, C., Codjia, G. (2005) Evidence for diet and chronic disease relationships requires food composition data. 6th International Food Data Conference, Pretoria, South Africa.

Charrondiere, U.R., Chevassus-Agnes, S., Marroni, S., Burlingame, B. (2003) Impact of Different Macronutrient Definitions and of Energy Conversion Factors on Energy Supply Estimations. 5th International Food Data Conference, Washington, USA.

Charrondiere, U.R., Vignat, J., Møller, A., Ireland, J., Becker, W., Church, S., Farran, A., Holden, J., Klemm, C., Linardou, A., Mueller, D., Salvini, S., Serra, L., Skeie, G., van Staveren, W., Unwin, I., Westenbrink, S., Slimani, N., Riboli, E. (2001) The European Nutrient Database (ENDB) for Nutritional Epidemiology. 5th International Food Data Conference, Bratislava, Slovak Republic.

Charrondiere, U.R. (2003) Towards a European Food database. Proceeding of the 9th European Nutrition Conference, Rome, Italy, 1-4-October 2003 in Annals of Nutrition and Metabolism.

Charrondiere, U.R. & Riboli E. (2001) The European Prospective Investigation into Cancer and Nutrition (EPIC). In: Proceedings of the 4th European Forum for Dieticians, Assisi, Italy, 20-23 May 2001.

Charrondiere, U.R., Vignat J, Slimani N, Riboli E, Day N. (2000) Economic Approach to Calculate Standardized and Calibrated Nutrient Intake across the 10 European Countries involved in EPIC. Proceedings of the Fourth International Conference on Dietary Assessment Methods in Tucson, USA, 17-20 September 2000.

Charrondiere, U.R., Slimani, N., Deharveng, G., Riboli, E. (1998) Standardisation of Portion Sizes in a 24-h-recall Software (EPIC-SOFT) used for EPIC in 9 Countries. Abstract in *European Journal of Clinical Nutrition,* 52 suppl 2 May S28.

Slimani, N., Deharveng, G., Charrondiere, U.R., Riboli, E. (1998) Standardisation of a computerized 24-hour Diet Recall Interview Programm used in a large International Multi-centre Study EPIC. Abstract in *European Journal of Clinical Nutrition*, 52 suppl 2 May S14.

Invited speaker while being Baby-friendly Hospital Initiative (BFHI) coordinator for Europe (1992-1993) to present goals, principles and progress of the Baby-Friendly Hospital Initiative (BFHI) in Europe:

- Meeting on Baby-Friendly Hospital. Eco Oko Center/Ministry of Health. Warsaw, Poland. October 1992
- Workshop on the Role of Maternity and Pediatric Services in the Protection and Promotion of Breastfeeding. Debrecen Hospital/UNICEF. Debrecen, Hungary. October 1992
- Seminar on Breastfeeding. IBFAN. Strasbourg, France. October 1992
- National Introduction Seminar of BFHI. Directorate of Health. Oslo, Norway. March 1993
- National Congress of the Working Group of Independent Mother Support Groups (AFS). Cologne, Germany. April 1993
- International Workshop on Breastfeeding and BFHI. Russian Federation. August 1993.
- Seminar “Towards BFHI”. UNICEF/Ministry of Health. Luxembourg. November 1993

Charrondiere, U.R. (1991) Is it necessary to observe a decline in breastfeeding rates in modern societies? What is the role of maternity hospitals? Fourth National Workshop on Breastfeeding. WHO/Shanghai First Maternity and Infant Health Institute. Shanghai, China.

Charrondiere, U.R. (1990) WHO/UNICEF Statement on Breastfeeding. National Workshop on Breastfeeding in Manila, Philippines. Ministry of Health/WHO.

Annex 2

CURRICULUM VITAE

Name:	Charrondière, Ute, born Arndt (calling name Ruth)
Address:	Via di Villa Aquari 5 00179 Roma, Italy Tel.: + 39 06 45 42 70 28
Date of birth:	9 October 1962
Place of birth:	Speyer, Germany
Nationality:	German
Civil status:	Married, two children (September 1990, June 1994)

Education

1979-1982	:	Helene-Lange-Gymnasium in Mannheim, Germany, a special high school for nutrition and home economics: Abitur (=high school diploma)
1982-1986	:	University of Kiel, Germany: Vordiplom in Oekotrophologie (=Bachelor's in nutrition)
1986-1988	:	University of Kiel, Germany: Diplom in Oekotrophologie (=Master in nutrition)
1990-1992	:	Université Paris V, France: Diploma in applied medical statistics, specialization in epidemiology, delivered by C.E.S.A.M.
2008-present	:	Doctorate at the University of Vienna, Austria

Work Experience

September 2002 to present: Nutrition officer at FAO, Rome, Italy, working on:

1. Food composition, mainly through INFOODS (International Network of Food Data Systems)

- Standard setting in component nomenclature and data interchange:
  - Co-organized Technical workshop on "Food energy - methods of analysis and conversion factors" in 2002 and Technical workshop on "Standards for food composition data interchange" in 2004.
  - Updated INFOODS food component identifiers and organized technical workshop in Bangkok, Thailand, in 2009.
- Capacity building at international and national level to generate, manage and use food composition data:
  - Was technical editor of the Greenfield and Southgate book on 'Food composition data – production, management and use, 2003. Supervised translation into French and Spanish.
  - Lectured in nine food composition courses: 2002 and 2005 in South Africa; 2003, 2005, 2007 and 2009 in Wageningen; 2006 in India, 2008 in Iran, and 2009 in Benin). In the 2005 Wageningen course, I was also co-director, and co-organized the courses in Iran (2008), Benin (2009) and Ghana (2009).
  - Assisted Lesotho (2002-2005) and Armenia (2006) to prepare national food composition table.

  - Developed and gave the a short course at University of Vienna 'Correct use of food composition data' together with H. Freisling (2008), and developed and gave a modified form based on distance learning (2009).
  - Published the Food Composition Study Guide (2009) in two volumes together with B. Burlingame, S. Berman and I. Elmadfa.
- Designed and implemented web-based Nutrient database and underlying management system to be published at FAO website.
- Co-organized and participated in 5th, 6th, 7th and 8th International Food Database Conference (2003, 2005, 2007, 2009).

2. Biodiversity and nutrition
- Assisted Laos to carry out a simplified food consumption survey on aquatic animals and plants in rice based ecosystems.
- Co-organized the Expert consultation on "Nutrition Indicators for Biodiversity for food composition, São Paulo, Brazil, on 21 October 2007. Also wrote the report and coordinated its translation into French and Spanish.
- Co-organized the Expert consultation on "Nutrition Indicators for Biodiversity for food consumption, Washington, USA, 8-9 June 2009.

3. Food safety
- Exposure assessment of contaminants and food additives:
  - Since 2008, panel member of the EFSA Scientific Panel on food additives and nutrient sources added to food (ANS).
  - Participated in six JECFA meetings (Joint FAO/WHO Expert Consultation on Food additives and Contaminants) as FAO staff member with expertise on dietary assessment. Part of a working group developing a new exposure assessment methodology for flavouring agents.
  - Participated in the WHO/FAO workshop on Dietary Exposure Assessment of Chemicals in Foods, Annapolis, USA, 2005.
  - Participated in the WHO/FAO technical consultation on 'Benefits and Potential Risks of the LP-s of Raw Milk Preservation', Rome, Italy 2006.
  - Participated in the 2005 EFSA scientific colloquium on European Food Consumption Database: Current and Medium- to Long-Term Strategies.
- Risk-benefit analysis:
  - Participated in the 2006 EFSA scientific colloquium on Risk-Benefit Analysis of Foods.
  - Co-Organized and participated in the Expert Group Meeting on the "Risks and Benefits of Fish Consumption", Rome in May 2007.
  - Co-Organized and participated in the Expert Consultation on "Risks and Benefits of Fish Consumption" in Rome in January 2010.
- Total diet studies (TDS):
  - Lectured in six TDS workshops: 2002 Czech Republic, 2004 in France, 2006 in China, 2007 in Egypt and Indonesia, and 2010 in Cameroon.
  - Assisted Cameroon (2006-2007) and Tunisia (2008-2010) to implement a total diet study.
  - Member of the EFSA working group on Total Diet Studies (since 2010)

March 1995 to September 2002: Technical officer at the International Agency for Research on Cancer (IARC) in Lyon, France

Main responsibilities in the European Prospective Investigation into Cancer and Nutrition (EPIC) study:

- Assisted 10 countries to standardize their country-specific versions of EPIC-SOFT, a software for 24-h-dietary-recall interviews developed at IARC.
- Was responsible for the development of a standardized food composition table for the 10 countries involved in EPIC. This involved the scientific and administrative planning and coordination of the work of national food composition compilers and EPIC collaborators; collecting and standardizing compositional data; developing databases; preparing guidelines and documents; writing scientific articles and grant applications; formulating requirements for a data management and interchange software; organizing meetings and scientific presentations at international meetings and conferences.

June 1992 to December 1993: Consultant as the Coordinator for the Baby-Friendly Hospital Initiative (BFHI) in Europe with UNICEF in Geneva, Switzerland

Main responsibilities:

- Coordinated the planning, implementation, and evaluation of the programme at national and regional level in close collaboration with WHO, National UNICEF Committees and NGOs.
- Organized and lectured in International training workshops and meetings on breastfeeding and BFHI.
- Assessed hospitals' breastfeeding programmes.

May 1989 to April 1991: Associate Professional Officer (APO) in Nutrition in the Western Pacific Regional Office of the World Health Organization (WHO) in Manila, Philippines

Main responsibilities:

Worked in the fields of breastfeeding, complementary feeding, food and nutrition policy, and the integration of nutrition in medical and paramedical curricula:

- Wrote reports on above subjects.
- Assisted countries in implementing projects.
- Participated in national and regional meetings and gave a number of lectures.
- Reviewed research projects.
- Co-organized the WHO workshop on Breastfeeding and its Effect on Fertility in Manila, April 1991.

September 1988 to January 1989: Nutritionist with the Federation of Red Cross and Red Crescent Societies working in Addis Abeba, Ethiopia

Main responsibilities:

- Evaluated the food aid activities of the Red Cross and Red Crescent Societies in Ethiopia through nutritional monitoring
- Trained local staff in anthropometric survey methodology and data analysis.

Courses

1985:	Trained as a nursing assistant with the German Red Cross
1985:	Participated in Course in Medicine in Developing Countries at the Institute for Tropical Hygiene in Heidelberg, Germany
1991:	Participated in Course in Applied Nutrition at the International Children's Centre in Paris, France
1991:	Participated in the Lactation Management course in Manila, Philippines
2004-2006:	Participated in the following courses: Negotiation course (2 days) Handling difficult situations (2 days) Presentation skill: Influence Your Audience (2 days) Facilitation course Guide Group Decision Making (2 days) Facilitation course Design Facilitated Events (2 days) Interpersonal Communications Skills Course (2 days)

Practical training

May-June 1984:	Administrative assistant with Operation Handicap International (OHI) in Bangkok, Thailand.
Nov - Dec 1984:	Staff member of CARE. I was responsible for the dietary section of a refugee camp hospital in Thailand, which included training of local staff in dietary calculations.
September 1986:	Volunteer nutritionist in the paediatric ward of the Central Hospital in N'djamena, Chad: I established a nutritional plan for infants using local foods.
July - Sept 1998:	Intern in the Nutrition Unit of WHO in Geneva, Switzerland: reviewed national nutrition plans and evaluation methods, including anthropometry.

Languages

German:	Mother tongue
English:	Fluent (level C)
French:	Fluent (level C)
Spanish:	Basic (level A)
Italian:	Basic (level A)

Annex 3

Published article: Charrondiere, U.R., Burlingame, B., Berman S, Elmadfa I. (2009). Food composition training: Distance learning as a new approach and comparison to courses in the classroom, Journal of Food Composition and Analysis 22 (5), 421–432

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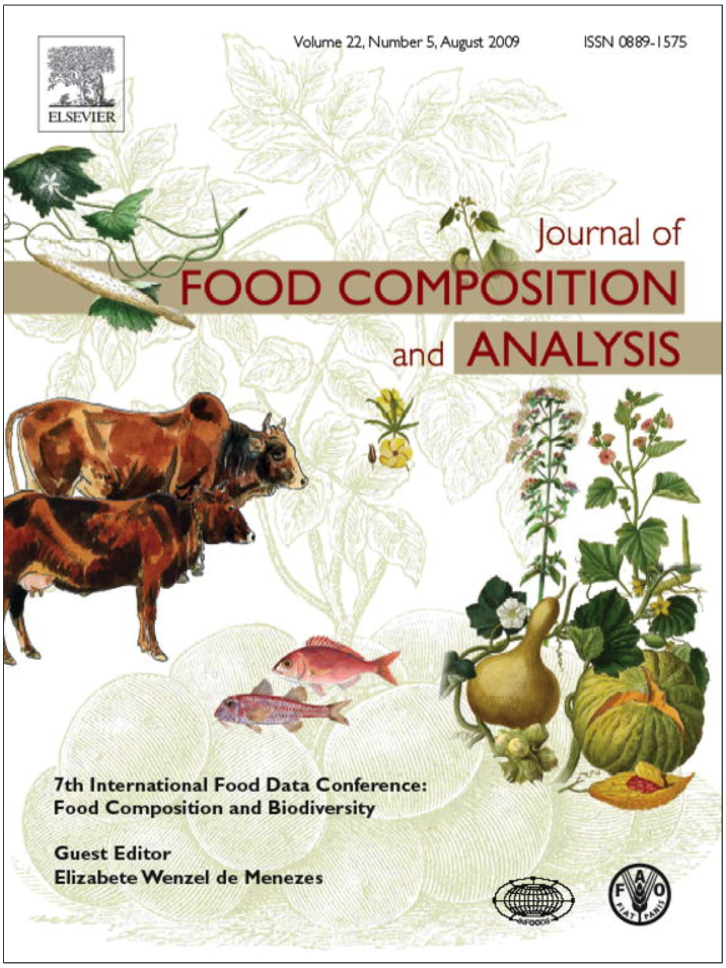

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Journal of Food Composition and Analysis 22 (2009) 421–432

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

journal homepage: www.elsevier.com/locate/jfca

Original Article

Food composition training: Distance learning as a new approach and comparison to courses in the classroom

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ARTICLE INFO

Article history:
Received 25 August 2008
Received in revised form 30 April 2009
Accepted 4 May 2009

Keywords:
Food composition
Training
Distance learning
E-learning
Capacity building
Nutrition

ABSTRACT

Food composition training courses in classrooms, which have been given since 1992, have reached approximately 500 professionals worldwide. In many fields distance learning is being increasingly used as it provides a means to reach a wider audience more cost effectively, which otherwise might never be able to access the knowledge being disseminated. The *Food Composition Study Guide* is being developed for worldwide use by FAO and INFOODS as a distance-learning tool to assist students gain knowledge on food composition and be able to evaluate their knowledge acquisition and ability to perform. The *Study Guide* was designed based on instructional and learning principles with the aim of helping students to fill their specific knowledge gaps, i.e. by choosing the modules of interest, and to perform better when generating, managing or using food composition data. It will be published in English, French and Spanish. The *Study Guide* is divided into 15 modules, each of which includes learning objectives, required reading, questions and exercises. With the points obtained through correct answers the learner is able to evaluate whether or not knowledge gaps have been filled. The *Study Guide* was compared with three classroom food composition training courses in terms of organization of course, participants/learners, content, instructional principles, learning principles, and evaluation. The *Study Guide* compares well with the courses in terms of content, but differs in design and delivery, and moreover lacks interaction among teachers and students. The *Study Guide* has a standardized quality and it reaches a wide audience cost-effectively, and because it was developed using instructional and learning principles and includes many exercises, it might be effective in keeping learner motivation high to acquire knowledge and building the confidence necessary to apply this knowledge in real job situations. Although the *Study Guide* is mainly designed as a stand-alone tool, it is also useful in conjunction with food composition courses, either prior to the course to increase the knowledge of students with little or no knowledge of food composition, at the end of sessions to evaluate learning, or after the course as a refresher.

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1. Introduction

Relevant, reliable and up-to-date food composition data are essential for nutrition and food-related areas. Without these data, neither developed nor developing countries can accomplish the following tasks effectively:

- analyse nutrient intakes and develop nutrient requirements;
- carry out epidemiological research on the relationship between nutrient intake and disease, also in relation to biodiversity;
- produce accurate food labels;
- formulate institutional and therapeutic diets;
- promote nutritionally important plants and animals to improve health or for breeding programmes;
- inform consumers about good food choices;
- develop nutrition-related policies, e.g. in the health and environment sectors (Greenfield and Southgate, 2003; Pennington et al., 2007; Burlingame, 2004; Willett, 1998; Riboli et al., 2002; Charrondiere et al., 2002; IOM, 2003; FAO/WHO, 2004; Vorster et al., 2007; Englberger et al., 2003; Hagenimana et al., 1999; Toledo and Burlingame, 2006).

If poor-quality food composition data are applied, errors can arise in applying them, but also subsequently in decision-making, e.g. faulty research results may lead to the wrong decisions in policies and programmes, or errors in labels may result in incorrect health claims and may result in trade barriers or may lead consumers to make the wrong food choices (Burlingame, 1998).

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0889-1575/$ – see front matter © 2009 Published by Elsevier Inc.
doi:10.1016/j.jfca.2009.05.001

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Training in food composition is a prerequisite to be able to generate relevant and high-quality food composition data, and to manage and use them correctly. The aim of INFOODS (International Network of Food Data Systems) is to improve the quality and availability of food composition data worldwide. INFOODS, together with other organizations, is therefore involved in carrying out food composition training courses (INFOODS, 2009a). Twenty-one courses on the topic, "Production and use of food composition data in nutrition" have been held since 1992. Eight courses were organized in Wageningen (Netherlands), by the Graduate School VLAG (Advanced Studies in Food Technology, Agrobiotechnology, Nutrition and Health Sciences) and the Division of Human Nutrition of Wageningen University in collaboration with partners including the United Nation University (UNU), Food and Agriculture Organization (FAO) of the United Nations, COST action 99/ EUROFOODS, International Union of Nutrition Societies (IUNS), and the European Food Information Resource Network (EuroFir). In addition to the courses in Wageningen, 12 regional courses have been conducted: three in Latin America (Chile in 1995, Argentina in 1996, Jamaica in 2001); five in Africa (1997, 1999, 2002, 2005 and 2009), two in Asia (Thailand in 2002 and India in 2006), one in the Near East (Iran in 2008), two in Europe (Slovakia in 2006, 2008) and one in Oceania (Australia 2009). These regional courses were organized by the local host, often in collaboration with regional and national organizations, other partners such as VLAG, the Wageningen University, UNU, FAO, INFOODS, the International Nutrition Foundation (INF) and/or EuroFir. The courses contribute to capacity building and strengthening of food composition activities at national and regional level, and therefore will improve the availability, comparability and quality of food composition data.

Of the approximate 500 course participants since 1992 (INFOODS, 2009a), some have taken up key positions in their countries and regions in the implementation of food composition programmes and have become trainers on food composition. Others have left the area of food composition. However, there are still a large number of professionals and students in need of basic or advanced knowledge and training in food composition. As global access to the Internet widens, including in developing countries (International Bank for Reconstruction and Development/World Bank, 2008), it is feasible to reach those interested in learning about food composition and good database practices worldwide through distance or e-learning.

Distance learning is a formalized teaching and learning system specifically designed to be carried out remotely by using electronic communication through correspondence courses, television courses, CD-ROMs, printed material, the Internet, or through other communication technologies such as telephone, satellite, or Internet chat. It can also be combined with classroom instruction. Distance learning is often used as a synonym for e-learning, but e-learning is restricted to learning using electronic means (Rosenberg, 2001). Distance learning and e-learning are increasingly used at many levels and in various domains such as for primary schools (FSA, 2008), high-school and university education (University of Bridgeport, 2008) and in training professionals (Learning centre, 2008; Codex Alimentarius, 2005; FAO, 2009) as well as in companies (Rosenberg, 2001).

The demand for food composition training is expanding in response to changes in biodiversity, plant breeding, dietary diversity, food industry, food safety and food regulation, to give just a few examples (Greenfield and Southgate, 2003; FAO, 2008). Therefore, demand for training by far exceeds the supply of food composition training courses. Through distance learning it becomes possible to bring information and knowledge on food composition to students who would not otherwise be able to obtain it. In this way students can fill their specific knowledge gap. Up to now, no distance, e- or on-line training in food composition has been available. Therefore, the *Food Composition Study Guide*' (referred to hereafter as *Study Guide*) is being developed by FAO and INFOODS as a distance-learning tool mainly for self-learning. This article first describes the basis on which the *Study Guide* was developed and proposes how it can be used, and then compares use of the guide with actual classroom food composition training courses.

2. Materials and methods

2.1. Material

For the *Study Guide* (FAO, 2007), the outline, unpublished modules, evaluation reports of the pilot and field tests, and preparatory work in terms of instructional design were used to extract information for the comparison. For the three food composition courses (8th International Graduate course held in Wageningen, the Netherlands, in 2007, the Second Asia course held in Hyderabad, India, in 2006 and the 4th ECSAFOODS course held in Pretoria, South Africa, in 2005) the material examined includes course brochures, programmes, presentations and the evaluation reports (ARC, 2005; NIN, 2006, 2007; EuroFIR, 2007).

2.2. Methods

The three food composition courses and the distance-learning tool were compared using the following criteria:

- *Organization of course*. The following characteristics of the courses were examined and compared: objectives, length of training, structure of training, resources of organizers, sponsors, information dissemination about training, selection of participants, cost of the course, accessibility (number of participants) and certificate.
- *Participant/learner*. Characteristics of the learner, which influence their ability to access and profit from training, were examined and compared: participant profile and flexibility for learner (time, location, needs).
- *Content*. The content of the courses and of the distance-learning tool is compared in terms of topics covered. Use of food composition data, Food composition programme, nutrients and components, foods, sampling, quality of data, analytical methods, compilation, documentation/interchange, biodiversity, other topics, visits, country presentations and project work.
- *Instructional principles*. Instruction or training is more effective when delivered using instructional design (Morrison et al., 2004; Smith and Ragan, 1999) to assure that it takes into account the profile and needs of the learners. Therefore, the quality of instruction is assessed using Instructional design principles and Bloom et al.'s (1956) (Bloom's Taxonomy, 2008) taxonomy of cognitive objectives: knowledge, comprehension, application, analysis, synthesis, and evaluation.
- *Learning principles*. The training was examined to determine the extent to which selected learning principles according to Bloom et al. (1956) were taken into account: cognitive learning principles (previous knowledge and long-term memory transfer); quality of instruction (quality of lectures, interaction/ information sharing and feed-back); affective learning principles (motivation/attitudes) and mastery learning.
- *Evaluation/assessment*. The unpublished written evaluation reports of the classroom courses (NIN, 2006; EuroFIR, 2007; ARC, 2005) that were written at the end of the course and 6 months later when available (NIN, 2007), as well as observations when teaching in courses and of six participants on the job after having attended a course, were used. An additional criterion was used to assess if learners acquired knowledge through the training.

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3. Results and discussion

3.1. Distance-learning tool: Food Composition Study Guide as a stand-alone tool

Those wishing to learn about food composition not only need to have access to publications about food composition (e.g. Greenfield and Southgate, 2003), but also must know if they have understood the information and knowledge and are able to apply it on the job. FAO and INFOODS developed the *Study Guide* to fill this gap. It allows students to structure their learning and to assess themselves in a flexible way so that they can determine where their knowledge gaps are and to complete them through further studying. The *Study Guide* comprises mainly questions and exercises through which points can be accumulated. The achieved score will then allow the students to assess their own learning performance. It is based on *Food composition data—Production, management and use* (Greenfield and Southgate, 2003), and was supplemented with other publications (e.g. Klensin et al., 1989; Rand et al., 1991; Klensin, 1992; Schlotke et al., 2000; FAO, 2003a,b; JFCA, 2006; EuroFIR, 2009 documents) to cover emerging issues and the topics of food composition that are less covered in Greenfield and Southgate (2003).

The *Study Guide* was developed using principles of instructional design (Morrison et al., 2004; Smith and Ragan, 1999) which were adapted for the purpose (see Table 1):

1. definition of goals through instructional analysis, i.e. investigation of the profile of the learner (e.g. previous skills, education, motivation, time available, location, means to assess information);
2. definition of the tasks they should be able to perform;
3. definition of instructional strategy and medium, i.e. selection of content, means, size and sequence of units, and the media, and delivery and
4. development of an evaluation strategy of the *Study Guide* to investigate scientific correctness, comprehensive coverage of topics, and comprehension by students.

The *Study Guide* is presented in 15 modules (see Table 2) that divide the learning content into smaller units. For each module, the learning objectives are stated and the student is invited to first read specific material, then to answer questions and to complete exercises. Most questions are multiple-choice questions and some are open questions, i.e. the student has to formulate the response in full. The first questions of any module are usually on definitions, followed by questions on knowledge (e.g. list, match) and comprehension (e.g. select, rank), which brings the students through the different steps to understand principles of the topics and their importance for data quality. In case a knowledge gap is encountered, the student is advised to return to the pages in the publication to find the correct answer. The exercises apply the new knowledge, which reinforces better comprehension. For some exercises, an instrument was needed to allow students to practise recipe calculation, compilation and documentation. Therefore, the Compilation tool version 1.1 was developed in Excel, which is available through the INFOODS (2009b) website. Some exercises ask the learner to use the new knowledge in different contexts such as searching information (on Internet or in reference material), calculating (e.g. nutrient intakes, recipes or values), assembling (e.g. a budget, missing values, compilation of values with documentation), rating (actions) or arguing (inclusion or exclusion of data). The questions and exercises were constructed by addressing all six levels of the Bloom et al.'s (1956) (Bloom on-line, 2008) taxonomy of cognitive objectives: knowledge, being the lowest level, followed by five increasingly more intellectual levels such as comprehension, application, analysis, synthesis, and evaluation. As the *Study Guide* addresses all six intellectual levels, it is expected that the knowledge is well integrated and can be retrieved in job performance (Smith and Ragan, 1999). In addition, information disseminated through the *Study Guide* is standardized and accessible to all potential users at the time the information is needed.

The *Study Guide* was designed to be used as a stand-alone tool for self-study, i.e. students complete the module(s) of interest without additional instruction. However, if the *Study Guide* is used as stand-alone learning tool it could be less effective, as is most distance learning without interaction, compared to a combined use with a food composition course. However, the value of self-learning should not be underestimated, especially for those who will never have a chance to attend a food composition course or who are only interested in certain subjects and not in a whole course. The *Study Guide* will be most useful in developing countries where many people are expected to acquire knowledge as self-learners. The *Study Guide* will be available free of charge through the INFOODS (2009a), INFOODS (2009c) websites in English, French and Spanish, as well as in printed form as separate volumes of questions and exercises, and their answers with the self-assessment categories. There are also plans to provide CD ROMs with the modules and the listed reference material for those with limited Internet access. For many questions, the computer or the Internet is not mandatory, but they are needed for some questions and many of the exercises.

3.2. Combined classroom and distance learning

The *Study Guide* can also be used in conjunction with a food composition course, either prior to a classroom course to increase initial knowledge, or, during or at the end of classroom courses to evaluate learning, or after a course as a refresher. The challenge in the instructional design of courses in general is to assist learners to accomplish the five higher intellectual levels, i.e. comprehension, application, analysis, synthesis and evaluation (Smith and Ragan, 1999). However, many courses deliver mainly information and knowledge, i.e. the lowest cognitive level. Learners with low levels of prior knowledge would profit from a pre-course, e.g. through the *Study Guide*, to increase their level of knowledge of the participants so that the course can place more emphasis on activities of the higher intellectual levels which could make the course more effective and interesting. The combination of the *Study Guide* and classroom instruction could make it possible to shorten the length of classroom courses and thus save funds (Morrison et al., 2004; Rosenberg, 2001). The *Study Guide* was successfully tested in three classroom courses in Iran, Austria and Benin where some of the modules were used to reinforce understanding and performance.

3.3. Comparison of three food composition courses given in the classroom and the Study Guide

Three food composition courses (Wageningen course of 2007, Second Asia course of 2006 and the ECSAFOODS course in South Africa of 2005) were selected to represent the courses given in the different parts of the world and over time since 1992. They were compared to the *Food composition Study Guide* in terms of the organization of course, participants/learners, content, instructional principles, learning principles, and evaluation (see Table 3).

3.4. Organization and participants

The classroom food composition courses were organized with the aim of showing how the quality and usefulness of food composition data are determined by the quality of generated analytical data of nutrients in foods and of the compilation process

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Table 1
Instructional design principles used in the development of the *Food Consumption Study Guide*.

Elements	Compilers	Analysts	Users
Profile of potential learners	- National and regional compilers - Researchers and others compiling specialized databases	Involved in food composition data generation, e.g. chemists	- Dieticians and other professionals using nutrient intakes and contents for different purposes - Researchers in need of food composition data and their metadata to evaluate comparability and compile a database - Teachers in nutrition and related fields
Characteristics of users, analysts and compilers	- Higher educational background (e.g., nutritionists, dieticians, epidemiologists, chemists): students, professionals - Fluent in English, French or Spanish - From developing and developed countries - Working in institutes, government organizations, laboratories, etc. - Various levels of previous knowledge of food composition - Varying knowledge gaps in food composition - Sufficient knowledge of the use of computers and Internet - In developing countries limited access to Internet - Some have experience with distance learning, others not - Unknown ability to work autonomously but it is assumed that people with previous on-line experience are more likely to succeed in working autonomously (Wojciechowski and Palmer, 2005)		
Tasks they should be able to perform	- Coordinate and manage food composition programmes - Integrate user's need - Elaborate sampling plan - Coordinate data generation though analysis - Compile and update FCDBs including building food list and selecting nutrients - Disseminate user FCDBs	- Collect, prepare, manage and stock samples properly - Generate high-quality data using adequate and up-to-date methods - Deliver compositional data together with meta data	- Identify correct match between foods consumed and foods in FCDBs - Distinguish between different nutrient expressions and their influence on nutrient intake - Calculate high-quality nutrient intakes - Apply food composition data adequately
Needed knowledge	- Foods and components - How to coordinate and manage a food composition programme - Sampling principles and techniques - Principles and quality of analytical methods - Quality assessment of data in databases - How to select most adequate data and data sources - Compilation techniques (recipe calculation, documentation) and programmes	- Foods and components - Detailed knowledge on analytical methods and their quality assurance schemes (this cannot be provided through this tool—only principles) - Sampling principles and techniques - Data documentation	- Foods and components - Prevention of errors when using food composition data - Compilation techniques (recipe calculation, documentation) and programmes - Data quality assessment
Strategy	- Distance-learning tool (similar to correspondence course) comprising reading of specific literature and evaluation of acquired knowledge through questions (multiple-choice, true/false, matching, open answer) and exercises (calculation, judgment, interpretation, organization) with points which will be used for self-rating/evaluation - Through Internet, CD, printed publication - On-line test foreseen in the future - E-learning course envisaged depending on funds - Stand-alone tool or in conjunction with classroom courses		
Special concerns	- Not all learners are fluent in English (therefore translation into French and Spanish) - Decrease in interest and motivation (therefore interesting questions easy to self-rate; adding an on-line test indicating own rating and that of other students is planned; certification)		
Evaluation of the instrument	- Peer review of each module - Field testing by previous students, new learners, in classroom courses - Planned prior to course, after course		

FCDB = food composition database.

of food composition databases. These courses demonstrated the benefits from the collaboration of users, analysts and compilers. The courses, with 20–29 participants, lasted 2 or 3 weeks (courses were initially 3 weeks long) and were intended for those involved in the production and compilation of food composition data, and for various other users. The courses were taught in English and comprised mainly of lectures, but also included group work, a few practical sessions, and a laboratory visit. The courses were organized locally in collaboration with international organizations or projects. The organization was very time-intensive before, during and after the course and included developing a programme; disseminating publicity; identifying sponsors; organizing lecturers, accommodation, computers, classrooms, etc.; selection of participants; assistance for participants to obtain fellowship, visa,

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Table 2
Modules/topics of the distance-learning tool *Food Composition Study Guide*—"Questions and Exercises".

1	Basic principles of a food composition programme
2	Use of food composition data
3	Selection and nomenclature of foods in food composition databases
4	Components in food composition databases
4.a	Component selection
4.b	Component nomenclature
4.c	Component conventions and units
4.d	Component methods of analysis
5	Sampling—principles, sampling plan, sample handling
6	Quality aspects of analytical data
7	Resources concerning food composition and publishing food composition information
8	Calculation—missing data, recipe calculation
9	Database management systems, metadata and data interchange
10	Compilation and documentation
11	Quality considerations in data compilation
12	Biodiversity

travel; and writing and communicating the evaluation of the courses. The course fees, which include tuition, material, accommodation and meals, amounted to 3400 Euro (US$5400) for the Wageningen course in 2007, US$1500 for the Second Asia course in India in 2006, and US$3,000 for the ECSAFOODS course in South Africa in 2005 (for South Africans US$650). In addition to the course fees, travel and medical insurance needed to be provided. In most cases, the participants did not pay the fees themselves, but obtained fellowships from UNU, INF, FAO, HarvestPlus, or EuroFIR.

Those interested in the classroom courses and who knew about the course though Internet, e-mails, brochures, or meetings, applied and were selected based on their CV and a motivation letter. In some cases, participants were not the most suitable because they were not able to assimilate the knowledge fully, or their work experience included limited areas concerning food composition, or because of their limited English. Students had to be present during the whole course; they could not choose only the topic(s) of interest. At the end of the course, all students obtained a certificate of attendance.

The *Study Guide* aims to enable students to understand the principles of food composition data generation, management and use, as well as the importance of user requirements and of data quality in data generation and compilation. In addition, students should be able to carry out good quality data generation and compilation, a simple sampling plan and apply data correctly. The *Study Guide* is intended mostly for compilers and professional users of food composition data and less for analysts. Analysts will not find detailed instruction on analytical methods, but will learn how their work integrates as part of the overall quality of food composition data. It is expected that a learner with little or no prior knowledge will complete most modules within 5 h and that the completion of all 15 modules would take about 75 h. Students with high prior knowledge on food composition would need substantially less time because less reading would be required. Any learner can download the *Study Guide* from the INFOODS website free of charge in English, French or Spanish, or order the CD ROM or printed booklets from FAO and then complete the questions and exercises independently with respect to time, location and pace; modules may be repeated as often as necessary.

3.4.1. Content

The classroom courses and the *Study Guide* are based on the publication *Food composition data—Production, management and use* (2nd ed., Greenfield and Southgate, 2003) while previous

Table 3
Comparison of food composition courses and distance-learning tool.

Criteria	Wageningen course in 2007	Second Asia course in India in 2006	ECSAFOODS course in South Africa in 2005	Food composition study guide – distance learning tool	Findings
Organization of course					
Objectives	- Demonstrate how quality and usefulness of food composition data is determined by quality of generated compositional analytical data and of compilation process into FCDB. - Demonstrate that preparation of FCDBs requires close understanding of the needs of the users by compilers and data generators. – Show benefits from collaboration of users, analysts and compilers			1. Understand: - principles of food composition data generation, management and use - data quality of analytical data and of compilation and their relevance to users 2. Enhanced performance of quality compilation, simple sampling, correct application of data (see also table 1)	Similar and Study Guide also on performance
Structure of training	- Country presentations - Lectures (mainly) - Exercises (few) - Project work (group or individual) - Visit (e.g. laboratory)			15 modules containing each: - Objectives - Required materials - Questions - Exercises - Answers - Self-scoring of results - If necessary repeat some sections	Different
Length of training	2 weeks	3 weeks	2 weeks	- Depends on knowledge of learner and number of modules completed - Estimated length of 5 hours per module/topic or 75	Different

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Table 3 (*Continued*)

				hours for all modules/ topics	
Resources of organizers	- Resource intensive in terms of staff time to organize and run a course			- High in staff time to develop tool - High in staff time to develop on-line course and certification, budget will have to be identified (planned)	Different
Sponsors	- Sponsors: EuroFir, UNU, Wageningen University - Division of Human Nutrition, self-paying participants	- Sponsors: INF, FAO, HarvestPlus, self-paying participants, Glaxo Smithcline	- UNU, INF, FAO, ARC, University of Pretoria, self-paying participants	- Not applicable	Different
Information dissemination about training	Though different websites, e-mails, meetings, conferences, universities, etc.				Same
Selection of participants	- Chosen from received applicants - Risk of choosing inadequate participants			- No selection - Everybody can use it	Different
Cost of course	- 3400 Euros (5400 USD) course fees per participant - Plus travel for participants - cost balance	- 1500 USD course fees per participant - Plus travel for participants and teachers - cost balance	- 3000 USD for foreigners - 650 USD for South Africans - Plus travel for participants - cost balance	- No cost for participants for internet version and CD - About 30 USD for printed book for developed countries - no cost balance as no course fees for participants	Different
Accessibility	29 participants	20 participants	21 participants	For any learner in any location with internet, or who is ordering CD or printed book from FAO	Different
Certificate	Certificate of attendance for every participant			- None so far - Planned in the future	Different
Participants / Learners					
Participant profile	- Compilers, data generators, users and teaching nutrition and nutritional aspects of food chemistry. - fluent in English			- Mainly for compilers and, users and for teachers and students of nutrition and related fields - For data generators on overall data quality but not on specific analytical methods - fluent in English, French or Spanish (see also table 1)	Similar
Flexibility for learner	- Absence from work place for course duration (2 or 3 weeks) plus travel time - Has to come to course location - The whole course has to be taken - No possibility to choose only subject(s) of interest - No possibility to repeat session(s)			- Any time at any location when convenient - Part(s) of the training or all modules - Can be repeated if necessary	Different
Content	- Based on "Food composition data – production, management and use" (Greenfield and Southgate, 1992 and 2003) - Other publications and resource material				Same
- Use of food composition data	- Use of food composition data in nutritional assessment - Consequences of random and systematic error in FCDB for nutritional epidemiology	- Introduction to food composition databases and the importance there-of - Use of nutritional data at the international and individual level - Use of nutritional data at the household level - Consequences of random and systematic error in FCDB for outcome/interpretation of nutritional epidemiological studies - Cancer and food composition databases - Need for good and compatible food composition data – role of INFOODS	- Introduction: Food composition and the importance thereof - Guidelines for the use of food composition data - User's needs (2 presentations) - Understanding components of nutrient intake - Food Labelling	- User requirements * - Users * - Impact on nutrient intake *	Similar

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Table 3 (*Continued*)

		- Food composition database and Codex - Food fortification and nutrition labelling			
- Food composition programme	-	- Introduction to food composition data & databases /initiation and organisation of database program - Role of INFOODS in food composition and organization of food composition programme * - Role of INFOODS in food composition data and FAO statistical databases	- How to initiate and organise a database programme - Organising a national food composition database - Background to INFOODS - Review of relevant development in other INFOODS Regional Data Centres	- Organising a food composition programme * - Budget considerations *	Similar
- Foods	- Setting priorities and selection of foods and nutrients - Food nomenclature, classification and identification in databases*	- Setting priorities and selection of foods and nutrients - Food nomenclature, classification and identification in databases	- Priorities: nutrients and foods (Selection of food) * - Food nomenclature	- Setting priorities and selection of foods * - Food nomenclature * - Food matching *	Similar
- Nutrients and components	- Setting priorities and selection of foods and nutrients - Approaches to identify food constituents - Conventions and modes of expression of food composition data	Setting priorities and selection of foods and nutrients - INFOODS approach to identifying food constituents - Conventions and mode of expression of food composition data	- Selection of nutrient and other components - Conventions and modes of expression of food composition data - Component identification	- Selection of nutrient and other components * - Component identification including tagnames * - Conventions and modes of expression of food composition data *	Similar
- Sampling	- Statistical principles underlying sampling procedures / assignments - Introduction to sampling of foods for analysis - Design of sampling protocols	- Statistical principles underlying sampling procedures - Design of sampling protocols * - Sample collection, handling and preparation of different matrices - National sampling plan for FCDB	- Sampling of foods for analysis	- Principles of sampling * - Design of sampling protocols * - Sample collection, handling and preparation of different matrices *	Similar
- Quality of data	- Laboratory data quality - EuroFIR harmonized approach to data quality - USDA approach in evaluating data quality - Quality considerations in the compilation process - Data quality evaluation of published values in literature/existing data *	- Reference materials and proficiency testing in food analysis - Quality control for nutrient analysis - Accreditation of the food analysis laboratory - Quality consideration in the compilation of food composition data - ISO 17025: potential application in generation of good quality FCD	- Data quality evaluation - Assuring the quality of analytical data and Quality control in the laboratory - Third party assessment in quality control - Quality considerations in the compilation of a food composition database - Harmonisation principles in data generation, compilation and dissemination in the region	- Laboratory data quality * - Quality consideration in the compilation of food composition data *	Similar
- Analytical methods	- Choice of analytical methods - Review of methods of analysis: - nitrogen, protein and amino acids - carbohydrates and dietary fibre - fat, fatty acids - fat soluble vitamins - water soluble vitamins - energy, water, ash, alcohol - in-organics	Choice of methods, method validation and verification - Moisture and its role in food composition data - NMR Spectroscopy - Ion exchange chromatography - nutrient analysis - ICPMS in Food analysis - Review of methods of analysis: - nitrogen, protein and amino acids - carbohydrates and dietary fibre - fat, fatty acids - fat soluble vitamins - carotenoids in foods - vitamin D and E in foods - water soluble vitamins	- Choice of analytical methods and their evaluation - Review of methods of analysis: - proximate system of analysis (water, total nitrogen, protein, amino acids) - lipid constituents (total fat, fatty acids, sterols) - carbohydrates (sugars, polyols, oligosaccharides, polysaccharides, resistant starch, glycemic index, NSP, dietary fiber) - alcohol, organic acids - energy	- Choice of analytical methods and their evaluation* - Review of methods for nutrients and other components, and their comparability *	Less in Study Guide

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Table 3 (*Continued*)

		- energy, water, ash, alcohol - in-organics - bio-active compounds - nutrient bioavailability - protein quality evaluation - glycemic foods, glycemic load and glycemic index - less familiar micronutrients	- inorganic constituents (Total ash, cations, anions) - water soluble vitamins - fat soluble vitamins		
- Compilation	- Collecting data from manufacturers, approaches and pitfalls - Standards development for Food Comp Databases: EuroFIR approach - Resources and publications on food composition data; role of INFOODS - Approaches in recipe calculations * - Basic principles for assembling and updating food composition databases - Database management systems	- Resources and publications on food composition data - Basic principles for assembling, management and updating of a food composition database - Data compilation and evaluation of a dataset: experience from resource persons - Locating, retrieving, evaluating, compiling and organising nutrient data* - Recipe calculations * - Database management systems	- Sources of food composition data and data bases - Food composition resources currently available e.g. food composition tables and nutritional databases - Computer based- Demonstration - Recipe and algorithm calculations *	- Sources of food composition data * - Recipe calculations * - Basic principles for assembling and updating food composition databases * - Database management systems *	Similar
- Documentation/ Interchange	Documentation and interchange *	Documentation and data interchange *	- Important principles of sample and data documentation - Intra-region data interchange, advocacy	Data documentation and interchange*	Similar
- Biodiversity	Bioversity, dietary diversity and food composition tables	Food composition and biodiversity	-	Bioversity and nutrition: dietary diversity and food composition data*	Similar
- Other topics	- Self learning	- Writing a research proposal: some suggestions - Osteoporosis: A case study - Micronutrient deficiencies: current status and future research needs - Lifestyle factors and chronic degenerative diseases - Future developments: forum of all faculty members	- Publishing food composition data - Carbohydrate Consultation - Current needs and future directions	- Instruction for self learning	Different
- Visits	NEVO, laboratory, library	2 laboratories	Laboratory	No	Different
- Country presentations on food composition	Yes	Yes	Yes	No	Different
Project work	Group work	Group work	Individual work	- No - Only possible when e-community build (future plans)	Different
Instructional principles					
Instructional design	No	No	No	Yes (see table 1)	Different
Bloom's cognitive levels of sessions/ modules	Knowledge 85% Comprehension 10% Application 5% Analysis 0% Synthesis 0% Evaluation 0%	Knowledge 85% Comprehension 10% Application 5% Analysis 0% Synthesis 0% Evaluation 0%	Knowledge 85% Comprehension 10% Application 5% Analysis 0% Synthesis 0% Evaluation 0%	Knowledge 35% Comprehension 15% Application 30% Analysis 10% Synthesis 8% Evaluation 2%	Different
Bloom's cognitive levels of project work (one topic)	Knowledge 20% Comprehension 20% Application 20% Analysis 15% Synthesis 20% Evaluation 5%	Knowledge 20% Comprehension 20% Application 20% Analysis 15% Synthesis 20% Evaluation 5%	Knowledge 20% Comprehension 20% Application 20% Analysis 15% Synthesis 20% Evaluation 5%	Not applicable	Different
Learning principles					
Cognitive learning principles: Previous knowledge and long-term memory transfer	- Various level of previous knowledge - Good transfer into long-term memory for topics with good previous knowledge - Good transfer into long-term memory for topics of project work as also higher cognitive levels involved - Lower for most lectures especially for learners with little or no knowledge (overload of short term memory)			- Various level of previous knowledge - transfer into long-term memory supposed to be good as acquisition of knowledge can be repeated and is applied in exercises	Different

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Table 3 (*Continued*)

Quality of instructions					
- Quality of lectures	Various qualities and messages depending on the lecturer, the selected content and the tools used			Standardized	Different
- Interaction, information sharing and feed back	Interaction between teachers and students and between students: - on country experiences - on course content - answer individual questions - provide additional information as needed - re-explain - social networking during and after course			- Not possible per se - Only possible if integrated in e-conferences, e-groups etc.	Different
Affective learning principles: Motivation/ attitutes	- To improve knowledge and performance of job - Through peers and physical presence - Acceptance to and certificate of an international course is helpful for career development - Discovery of new country and people			- To improve knowledge and performance of job - No motivation through peers' feed back, physical presence, social interaction or certificate - Through attractive design of material and quality knowledge transfer	Different
Mastery learning	- Limited because not possible to repeat sessions or no assessment of acquired knowledge (except for university students in ECSAFOODS course) - Possible through interaction with teachers and students and in group work			- Learners are encouraged to go back to the areas with knowledge gaps before proceeding to next module or being able to apply in job - Self-assessment of progress through self rating	Different
Evaluation/ Assessment					
Observations	- Too few exercises, therefore added in own lectures questions and exercises (which became part of the Food composition study guide) - When visiting selected participants after course who had little or no previous knowledge it was noted that very limited knowledge was retained - Participants with high prior knowledge and involved in food composition activities gained most and were able to apply aspects influencing data quality and appropriateness of data			Not applicable	Different
Assessment/Retention of knowledge	- No test to evaluate acquired knowledge	- No test to evaluate acquired knowledge	- Test to evaluate acquired knowledge for University students	- Self rating to test acquired knowledge	Different
Evaluation of training	At the end of the course, participants evaluated the relevance and usefulness of course with 4.0 of 5 points. More exercises should be proposed while condensing lectures. E-learning was seen a good tool to increase the knowledge of participants prior to the course.	- At the beginning of the course, participants had i mostly fair or limited knowledge on food composition issues. They indicated that they have acquired knowledge which is expected to be used after the course. Highest scores were given for issues related to use, foods, nutrients, sampling, data quality, resources (14-16 of 20 participants said good), less on analytical methods and (10-15 said good) and compilation issues (12-14 said good). - The evaluation 6 months after the course indicated that almost all participants had used the knowledge except for compilation (60%). Almost all were interested in refresher course, including distance learning, or at discussion groups.	At the end of the course, participants evaluated the relevance and usefulness of course with 4.15 of 5 points	- Positive In testing in three courses, self-learners: learned a lot but difficult	Similar

FCDB = Food composition database.
[a]Included exercises.

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courses were based on the first edition (Greenfield and Southgate, 1992). Additional reference material was used in the courses and the *Study Guide*, as the Greenfield and Southgate books do not cover all issues on food composition in detail.

All courses covered all relevant aspects of food composition. However, some courses had specific emphasis, e.g. the Second Asia Course also covered biodiversity and emphasized analytical methods and use. The Wageningen course did not cover the organization of a food composition programme but disseminated new developments from the EuroFir project and covered biodiversity and self-learning. A website of the course presentations and additional reference material was set up during the course and is available to students after the course (EuroFIR, 2007a). The ECSAFOODS course covered all issues but included only one lecture on sampling and none on biodiversity because, in 2005, biodiversity was not yet an issue. Several teachers lectured in the courses in their area of expertise, shared their experiences and covered also different topics beyond Greenfield and Southgate (1992, 2003). As a result, the content, quality and delivery of the lectures are not standardized, and courses differ depending on the lecturer.

The distance-learning tool covers all issues on food composition and the content is delivered in a standardized way. No modification of the content would be encountered as compared to classroom courses. The main difference to the courses is the means of instruction. In the classroom courses, topics were delivered mainly through lectures and group work while in distance learning students are required to read material and to answer questions and complete exercises.

3.4.2. Learning and instructional principles

It is not known to the authors of this article if the food composition courses have considered instructional design. On the other hand, the *Study Guide* was developed using instructional design principles (see Table 1).

The classroom courses mainly emphasized the transmission of information and knowledge, with less focus on comprehension, application, analysis, synthesis and evaluation. Only the group work gave the participants the possibility to apply the new knowledge to one topic, e.g. "Comparability of food composition databases"; "Strategies for development of a national food composition database for Nepal/Armenia" (country of one participant is selected); "Development of a specialized food composition database"; "Assigning the quality of data from different sources"; or "Data aggregation". The distance-learning tool was structured so that about 35% of the maximum achievable points would be obtained through acquired knowledge, 15% through comprehension, 30% through application, 10% through analysis, 8% through synthesis and 2% through evaluation. The application of new knowledge and skills (and consequently the transfer to the long-term memory) can be enhanced by giving learners the possibility to apply their learning to a variety of circumstances. The transfer to the long-term memory is assisted when the information is meaningful and can be integrated with related prior knowledge (Smith and Ragan, 1999). The *Study Guide* and the group work in the courses offer learners this opportunity.

Other factors that are important for successful learning are feed-back (e.g. teacher, peers), interest and motivation (Smith and Ragan, 1999; Rosenberg, 2001). Classroom courses allowed a high degree of interaction among students and teachers. Students exchanged information on country experiences, provided additional information on understanding of the course content, and networked socially during and after the course. Students received feed-back from peers and teachers, and received answers to their specific questions. These interactions are absent when distance-learning tools are used, and could only be added if e-conferences, e-groups or e-communities are created around the *Study Guide*.

Motivation and interest are important factors for learning. For classroom courses, motivation was considered to be high: participants came to improve their knowledge and their job performance, were physically present, received feed-back, and at the end of the course received a certificate of attendance which may be helpful for career development. In addition, it was normally a positive social experience (NIN, 2006; EuroFIR, 2007). In contrast, the only motivation when using the *Study Guide* is that learners are eager to acquire new knowledge. A key issue of distance and on-line learning are the high drop-out rates. Important criteria for satisfaction of an on-line course and low drop-out rates were responsiveness by the faculty and the quality of the instruction (Herbert, 2006), good marks, attendance at an orientation session, computer knowledge, successful completion of other on-line courses (demonstrating necessary independence and time management skills), and age of participants between 30 and 50 years (Wojciechowski and Palmer, 2005). Distance learning through the *Study Guide* does not include instructors or an orientation course, nor an external evaluation or a certificate. But we have attempted to maintain a high level of motivation by providing a high-quality and attractive tool to learners of different needs and different levels of prior knowledge. However, if the *Study Guide* were to be used as pre-course or in training courses as a distance learning course with an assessment, the motivation to complete the selected modules successfully would be increased and feed-back could be provided through a lecturer.

3.4.3. Evaluation/assessment

In previous years, there was a final test at the end of the course to assess the students' acquisition of new knowledge before obtaining the certificate of attendance. After 2003, every participant received a certificate of attendance without passing a test. The *Study Guide* permits a self-rating of the acquired knowledge and the performance if used as stand-alone tool.

In general, the evaluations of the courses by the participants were positive (NIN, 2006, 2007; EuroFIR, 2007; ARC, 2005). Participants appreciated the classroom course, the teachers, the interaction, the content and said that that they could apply this knowledge in their work. However, participants would have appreciated more practical application and fewer lectures. Some saw the value in distance learning to acquire knowledge before the course, while others would have appreciated refresher courses including through distance learning and e-communities. The classroom course seemed more effective for participants who had already worked with food composition data and therefore had a good level of knowledge in various issues related to food composition. For them, it was easy to relate the new knowledge to existing knowledge and experience and therefore assimilate the new concepts and information easily. They often arrived with specific questions or needs and appreciated how the different parts of food composition are interrelated and do influence the quality of food composition data and of their application. On the other hand, it appears that students with little or no previous knowledge of food composition had difficulty in assimilating the new knowledge during 2 or 3 weeks. They could not relate new information to existing experience or knowledge and the new information was rarely stored in their long-term memory. It happened several times that when these students were visited at their work place after the course even essential knowledge was lost and training had to restart. Reasons given include that there was too much information, that the new information was not applied, that the speed of the course was too rapid, or that due to language problems they had difficulties in following the course. A few students attended a course twice and recognized that they understood some issues only the second time.

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Five modules of the *Study Guide* were pilot-tested to assess its potential usefulness. Participants appreciated the modules and declared that they had learned or refreshed their knowledge. Suggestions for improvement were taken into account when modifying the modules. The modules of the *Study Guide* were peer-reviewed by two to four external experts before being tested in food composition courses in 2008 and 2009. The *Study Guide* will also be tested with new learners who are using the *Study Guide* as a stand-alone tool.

4. Conclusions

Food composition classroom courses are expensive, and potential sponsors have increasingly fewer funds. And for some participants, it is difficult to spend 2 or 3 weeks away from their jobs, or even to absorb the bulk of new knowledge conveyed during the course. The *Food Composition Study Guide* being developed as a distance-learning tool makes it possible to reach a wide range of learners, especially those in developing countries, so that they may acquire knowledge on food composition, apply it and then assess their level of acquired knowledge and performance. In this way, knowledge on food composition can be shared globally at a low cost for the user and in a way that allows students to learn where they want and at their own pace at a convenient time, and concentrate only on the topics of interest. In addition, the translation into French and Spanish makes it possible to reach more learners in their own language. The content of the courses and the *Study Guide* are similar, even though the *Study Guide* offers a standardized content and quality. The main differences are the delivery and level of application. The *Study Guide* is mainly intended to be used as a stand-alone learning tool for those not able to attend a formal course, and it can be used to reinforce a classroom course. It might be valuable to use the *Study Guide* as an information management tool, i.e. to transmit information and knowledge, which would enable the classroom course to concentrate more on higher intellectual levels, e.g. comprehension, application evaluation. This would make the *Study Guide* and formal courses more interesting and efficient. As indicated in the evaluation of the Wageningen course, course participants would appreciate this new approach.

The *Study Guide* could also be used in higher education institutions to allow future nutritionists and other professionals to have a better understanding of food composition. Offering certification of on-line learning on food composition is being envisaged, as well as the creation of an online community on food composition training in conjunction with FAO and INFOODS, so that e-conferences and/or e-working groups on specific topics of food composition using the *Study Guide* as a basis may be organized (implementation will depend on the availability of budget and other resources). It is hoped that these types of initiatives would help to increase learner motivation.

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Annex 4

Submitted article: Charrondiere, U.R., Freisling, H, Elmadfa, I. (2010). The distance learning tool 'Food Composition Study Guide' contributes to global capacity development in food composition

The distance learning tool 'Food Composition Study Guide' contributes to global capacity development in food composition

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Keywords: food composition; training; higher education in nutrition and dietetics, distance learning

Abstract

Food composition data underpin most activities in nutrition, and yet few universities and courses provide information on this topic. To address this problem, FAO/INFOODS developed a distance learning tool, the 'Food Composition Study Guide', comprising 17 modules covering all relevant topics on food composition in the form of questions, exercises and answers. It was used by 109 health and nutrition specialists and chemists in conjunction with classroom-based food composition courses, in a university setting (in a classroom-based seminar and as distance learning course), and by self-learners. The different applications were compared in terms of settings, objectives of the setting, participants, languages, modules used, modalities of use, evaluation by users, assessment of users, and lessons learnt. The Study Guide was useful for teachers to prepare lectures and to carry out courses; and for learners to acquire, deepen and elaborate their knowledge and skills in food composition. It proved successful in all settings. The Study Guide is a good means to fill the existing global training gap in food composition and can be used in universities, courses and by self-learners, either as distance learning or in classrooms. This will be enhanced through French and Spanish translation and distribution through Internet and CD.

1. Introduction

Food composition has a central role in nutrition, dietetics and food-related sciences because of its important applications: calculating nutrient intake estimations; determining nutrient requirements; in epidemiological research to establish relationships between nutrient intake and disease; calculating nutrient content for food labels; assembling institutional and therapeutic diets; including nutritionally-important plants and animals in breeding programmes; and informing consumers of good food choices. These applications have important implications for nutrition, health, and agriculture-related programmes and policies (Willet, 1998; Hagenimana, 1999; Charrondiere *et al.*, 2002; Riboli *et al.,* 2002, Englberger *et al.,* 2003; Greenfield and Southgate, 2003;

IOM, 2003; Burlingame, 2004; FAO/WHO, 2004; Toledo and Burlingame, 2006; Pennington *et al.*, 2007; Vorster *et al.,* 2007).

The quality of these data and their use depends on the knowledge of the professionals in food composition (Hollman et al., 2009). However, only about 550 professionals have been trained in food composition worldwide through expensive classroom-based postgraduate courses[13, 14] while it is hardly included in curricula of universities (Greenfield and Southgate, 2003). Especially in developing countries (Schoenfeldt, 2002), there is a great need to train more professionals in food composition and new approaches are needed to reach them in an economical and efficient way. As distance learning is increasingly used for education and training of professionals (University of Bridgeport, 2010; Learning center, 2010; Codex Alimentarius, 2005; FAO, 2010 a; Rosenberg, 2001), the Food and Agriculture Organization of the United Nations (FAO) and the International Network of Food Data Systems (INFOODS) published the distance learning tool 'Food Composition Study Guide' (Charrondiere *et al.*, 2009 b, c). It allows a wide range of learners (users, compilers and analysts) to fill their specific knowledge gap at their convenience at no cost, and to evaluate themselves. In this article it will be referred to as the 'Study Guide'.

The Study Guide covers food composition in the form of questions, exercises and answers. It is based on the principles of instructional design (Smith and Ragan, 1999), Bloom's taxonomy of cognitive objectives (Bloom *et al.,* 1956); INFOODS documents, including Greenfield and Southgate (2003), Klensin *et al*. (1989), Rand *et al.* (1991), Klensin (1992), FAO (2003, 2004; 2008); and EuroFIR documents (2010 b). The Study Guide content compares well with classroom-based food composition courses (Charrondiere *et al.*, 2009 a), was peer reviewed and field tested, and is most relevant to users and compilers of food composition data, but also to analysts. The Study Guide is to be used together with the FAO/INFOODS Compilation Tool (Charrondiere & Burlingame*,* 2010; INFOODS, 2010 b) to apply the compilation, calculation and documentation of food composition data. In September 2009, the Study Guide was published electronically in English on the INFOODS website and allows a wide range of learners to fill their specific knowledge gap at their convenience at no cost, and to evaluate themselves.

This article describes and analyses the different usages of the Study Guide in classroom-based food composition courses, in a university setting, and by self-learners, and illustrates new approaches food composition courses.

2. Material and methods

The two volumes of the Study Guide were used [20, 21]: volume 1 containing the questions and exercises, and volume 2 providing the answers and feedback. The content of both volumes is presented in 17 modules:

- Module 1: Basic principles of a food composition programme
- Module 2: Use of food composition data
- Module 3: Selection and nomenclature of foods in food composition databases
- Module 4a: Component selection
- Module 4b: Component nomenclature
- Module 4c: Component conventions and units
- Module 4d: Methods of analysing components
- Module 5: Sampling

- Module 6: Quality aspects of analytical data
- Module 7: Resources for food composition. Publishing food composition data
- Module 8: Recipe and other calculations
- Module 9: Food composition database management systems and data interchange
- Module 10: Compilation and documentation
- Module 10.a: Additional exercises on comparing and compiling data from food composition databases
- Module 10b: Additional exercises on translating food intake to nutrient intake
- Module 11: Quality considerations in data compilation
- Module 12: Food biodiversity

The unpublished evaluation forms, oral feedback and tests from self-learners and course participants (three postgraduate food composition courses and two at the University of Vienna) were utilized to evaluate the Study Guide in the different settings. The test criteria were learning objectives, participants, language, modules used, modality of usage, evaluation by users, assessment of users, and lessons learnt.

3. Results

Before field testing, all modules were peer reviewed and tested by 36 experts and professionals with knowledge on food composition. Experts found the Study Guide to be of high quality and their comments were used to rephrase and complete the questions, exercises, answers and additional information. Thereafter, the Study Guide was tested and implemented in three classroom-based international postgraduate food composition courses, in a university classroom setting as part of a nutrition curriculum, as a university-level distance learning course, and by self-learners (see **Table 1**).

3.1 In conjunction with classroom food composition courses

The Study Guide was field tested in three classroom courses in Iran, Benin and Ghana (INFOODS, 2010 a) as an integrated part of a food composition course to reinforce understanding and performance of participants. The modules were used during all three courses, and in two courses also as an information management tool to increase the knowledge of participants beforehand. Participants completed the questions and exercises in small groups using hand-outs of the lectures and the reference documents before discussing the results in the whole group. At the time of the courses, the Study Guide was not yet published, meaning that participants did not have access to the answers. The modules created many discussions and motivated them to share their experiences and understanding. The modules were highly appreciated by participants and by instructors. The Study Guide also assisted instructors to prepare their lectures, to hold the course and to develop the final test. The final test was a subset of the modules discussed during the course and all participants passed the test by reaching 60-90 % of the points.

3.2 In a university setting

At the University of Vienna, Austria, two courses on “Correct use of food composition data” were given, each counting for three ECTS credits (European Credit Transfer and Accumulation System).

Sixteen students attended the 3-day classroom course which consisted of 8 hours of lectures including discussion, 9 hours of exercises, 3-4 hours of homework and a 2-hour exam. In this course, modules 4.a, 4.b and 4.c were given as homework and parts of modules 2 and 10.b were used as exercises in the classroom. The course was innovative in two ways, first through the use of the modules and secondly that every lecture was followed immediately by an exercise using real data, i.e. the 28 foods from the Austrian food frequency questionnaire (FFQ), developed by Freisling *et al.* (2009), were put into food groups, coded, and were disaggregated into more specific foods. The draft Austrian Nutrient Database (OELS) was used to identify foods to apply their nutrient values to the FFQ foods and to match the components of the OELS to those of the Compilation Tool (Charrondiere & Burlingame, 2010).

In 2009, a distance learning course was given in which the six students completed modules 1, 2, 3, 4.b, 4.c, 7, 8, 10, 11, (about 55 hours) during three months. Thereafter, a one-day optional classroom interaction between students and instructors was held, queries were discussed, main points of the modules were summarized and some exercises were done based on module 10.b.

Both courses were successful as students acquired good theoretical knowledge and skills. In the classroom-based course, students increased their knowledge on food composition significantly between the initial and final test, corresponding to 2.8 grades on average (on a scale of 0-4). The tests for both courses had multiple-choice questions, which were selected from the modules covering the subjects treated during the course. About 90% of students obtained an A or B mark (on a scale of A to D).

3.3 By self-learners

In addition in 2009, the Study Guide was used by seven self-learners at FAO, Rome, and the University of Pretoria, South Africa. They needed to acquire relevant knowledge to carry out specific tasks related to food composition or food biodiversity. They used all modules, even though most of them completed modules 4.b- 4.d, 8, 10, 12, which took them 5-12 hours for each module. After completing the relevant modules, they were able to calculate nutrient values of recipes using different recipe calculation systems using the Compilation Tool; to collect relevant food composition data on food biodiversity from different sources and compile them into a food composition database using the Compilation Tool; and to develop and collect data for Nutrition Indicators for Biodiversity on food consumption (FAO, 2010 b). The approach of self-learning was highly beneficial for their supervisors as it saved a substantial amount of time for training and supervision while being assured that staff received the comprehensive and standardized knowledge needed to fulfil the specific tasks they were assigned.

Learners appreciated the modules because they acquired a lot of knowledge and skills, and because they were able to demonstrate that they had understood and assimilated the content of the course, even though they needed an appreciable amount of time to complete the modules. Most course participants would have appreciated to spend more time on the modules and to have them available in their first language. The Study Guide assisted them to better understand the course content, to keep their attention high even after many course hours, and to assess their knowledge and skills acquisition. They appreciated the value of certain modules (e.g. component nomenclature, conventions and units) only when compiling and calculating food composition data. The Study Guide also assisted instructors to prepare their lectures, to hold the course and to develop the final tests which were a selection of the multiple-choice questions from the modules. These tests showed that participants acquired a good theoretical knowledge and practical skills (60-90 % of possible points).

4. Discussion
The Study Guide has been used successfully in different settings, i.e., during and before food composition courses, in a university setting in conjunction with a classroom-based seminar and as a distance-learning course, as well as by self-learners. The modules represent a useful tool for:

- instructors, even for those with limited experience in food composition, to better prepare lectures or to run a course
- participants of distance-learning and classroom-based courses to acquire relevant knowledge and skills while reviewing the course content and by applying the newly-acquired knowledge
- self-learners to acquire the necessary knowledge and skills to successfully carry out tasks related to food composition or food biodiversity.

The Study Guide was shown to be useful in moving away from solely lecture-based training. Learning by completing the modules is very different from listening to lectures Lecture-based classroom courses allow interaction and take less time to address subjects, but there is no time to deepen the knowledge or to apply it, and normally knowledge acquisition is not assessed[14]. The learning approach of the Study Guide is in line with non-lecture based learning styles such as 'Learning-by-doing' or peer education (Khan et al., 2009) or interteaching (Goto and Schneider, 2009) using learning through exercises and discussions.

The Study Guide fulfils most of the quality criteria for distance and e-learning proposed by Baker (2003) and Mihai (2009) as it was developed using instructional design (Smith and Ragan, 1999) and Bloom's taxonomy of cognitive learning (Bloom et al., 1956). However, the criteria concerning an interactive format and a quick learning experience were not fulfilled because the Study Guide is a static document in two volumes, although it includes hyperlinks to all referred documents, and as it takes 3 to 9 hours to complete one module.

The Study Guide was used as an information management tool, i.e. students complete all or selected modules of the Study Guide as a pre-requisite for the course. This allows the classroom-based course to place more emphasis on activities of the higher intellectual levels (Bloom et al., 1956), which could make it more effective, interesting and result-oriented (Morrison *et al*., 2004; Rosenberg, 2001). However, it seems necessary to obtain a firm agreement from participants of food composition courses to complete the modules beforehand. Sending the modules at least one month before the course is preferable, but experience showed that not every participant will complete all modules, mostly because of lack of time.

Future course are planned without lectures, where the Study Guide will be used as an information management tool, and during the classroom instruction participants will compile a food composition database containing local foods and recipes and/or develop a sampling plan for a food. These outputs could be the basis for a national or regional food composition database. During these courses, trainers can be instructed to carry out future courses.

Professionals with advanced knowledge in food composition appreciated the Study Guide because it is systematically structured, comprehensive, of high quality, and they were able to learn something new. In many cases, they reported having skipped the reading and answered the questions and exercises but turned to the reading material when needed. Learners with little or no knowledge read the indicated material which took them often a substantial amount of time, especially for those for whom English is not their mother tongue or working language. Some of the recommended reading materials are only available in English, even though the modules will be available in Spanish and French. Even for native English speakers, some of the reading materials were considered difficult to comprehend. However, these materials are the authoritive sources and not subject to revision by the authors of the Study Guide. However, these difficulties represent real-life situations. Some answers were not found as such in the reading material, and learners needed to use their acquired knowledge to answer the question or exercise. Due to the difficulties encountered with the reading material and due to the fact that students seem less engaged in reading (Lee et al., 2009), it was decided to publish a revised version of the Study Guide in 2010 with more references to PowerPoint presentations, which summarize the content of each module and which will be available on the INFOODS website (2010 d). These presentations can also be used by lecturers to develop or customize their own lectures.

University students and self-learners (who needed to carry out specific tasks) were most motivated to complete the modules and obtained highest scores. The acquisition of knowledge and skills when completing the modules, with high or low scores, should however not be underestimated, as learners often returned to the reading material, checked the exact wording and meaning, used previous knowledge and thus deepened their understanding. Successful completion of the modules increased the learners' self-confidence in their acquisition of knowledge and understanding, and in their ability to work with food composition data.

It is also planned to test more approaches using Skype or other audio or communication tools for the personal interaction between instructors and learners. This approach, if reliable Internet connections were assured, could overcome the isolation felt by distance-course students (Owens et al., 2009), and would permit training with interaction where instructors and learners remain in their locations. These new approach could be especially useful in developing countries where there is the greatest need for capacity development in food composition (Schoenfeldt, 2002).

In addition, the Study Guide modules can be used to introduce food composition into the curricula of universities, e.g., as a distance learning course, a seminar or simply in lectures. The combination of distance learning with a one-day interaction with the teacher seemed to be highly profitable for students, which is in line with the positive feedback from other distance learning courses offering interaction with the instructor (Herbert, 2006).Occasionally, teachers in universities may need to acquire the relevant knowledge of food composition beforehand, e.g., through the Study Guide. Over 35 universities worldwide already expressed their interest in using the Study Guide in their curricula (personal communication).

The Study Guide is most useful for individual knowledge and skills acquisition. However, to transform the capacity building from individuals to that of their institutions, a positive political and institutional support and funding are essential

(Rosenberg, 2001; OECD, 2006), without which high quality food composition programmes and databases will not be developed and/or maintained (Greenfield and Southgate, 2003).

The Study Guide has however never been tested with self-learners who study solely on their own without any possibility to interact with a knowledgeable professional in the field.

4. Conclusion

The Study Guide offers to a wide range of individuals new possibilities to acquire the relevant knowledge and skills in food composition and thus can fill the global training gaps in food composition and food biodiversity, especially in developing countries. In addition, it allows instructors in universities and of postgraduate courses to prepare high- quality lectures and to hold courses on food composition without the assistance of international instructors. Through active communication by FAO and other channels, the translation of the Study Guide into French and Spanish, and the dissemination through CD ROMs with all course material (for those with no or limited Internet assess), it is expected that the Study Guide will be widely used in food composition courses, universities and by self-learners, either as distance learning or in classrooms.

The more nutrition professional are aware of the underlying tasks to develop an adequate, reliable and up-to-date food composition database and that the quality of nutrient intake estimation, research and policies depend on these data, the more likely it will be that more adequate food composition databases will be developed.

Acknowledgement

The authors are grateful for the contributions of the participants of the food composition courses in Iran, Benin Ghana and at the University of Vienna, Austria (2008, 2009). They also thank Karl-Heinz Wagner for the administrative arrangements to hold the two courses at the University of Vienna. The authors also would like to express their gratitude to George Annor, Barbara Burlingame, Mina Esmaeili, Pablo Eyzaguirre, Fatima Hachem, Cheikh N'diaye, Esther Sakyi-Dawson, Francisca Smith, and Raymond Vodouhe, for co-organizing the postgraduate food composition courses.

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Table 1: Comparison of different usages of the Study Guide in food composition courses, university setting and by self-learners and reviewers

	Food composition course in Iran (2008)	Course on food composition and biodiversity in Benin (2009)	Course on food composition and biodiversity in Ghana (2009)	University of Vienna as classroom course (2008)	University of Vienna as distance learning course (2009)	Self-learners and reviewers working in food composition area (2007-9)	Self-learners with little or no previous knowledge in food composition (2009)
Setting	Food composition course of 2 weeks in classroom organized by FAO.	Course on food composition and biodiversity of 2 weeks in classroom organized by FAO and Bioversity International.		3 days block seminar in classroom: 'Correct use of food composition data', counting for 3 ECTS credits. Lecturer: U.R. Charrondiere and H. Freisling.	Self-learning plus 1 optional day in classroom: 'Correct use of food composition data', counting for 3 ECTS credits. Lecturer: U.R. Charrondiere.	Pilot testing and peer review of modules by professionals working in food composition.	Volunteers, students or consultants to work with food composition data and/or on biodiversity (FAO, Rome; University of Pretoria, South Africa).
Objectives of settings	To enable participants to generate, manage, compile and use food composition data correctly. To investigate understanding and quality of modules.			To enable participants to manage, compile and use food composition data correctly. To investigate understanding and quality of modules.		To investigate usefulness, understanding, completeness, quality and necessary improvements of modules.	To compile, calculate and use food composition data correctly and/or to work on biodiversity.
Participants	15 nutritionists, chemists and other health and nutrition specialists working in government agencies.	15 nutritionists, chemists and other health and nutrition specialists working in government agencies, NGOs, private sector and universities.	14 nutritionists, chemists and other health and nutrition specialists working in government agencies, NGOs, private sector and universities.	16 master and PhD students in nutrition of the University of Vienna.	6 master and PhD students in nutrition of the University of Vienna.	36 nutritionists, chemists and other health and nutrition specialists working in government agencies, private sector and universities.	5 nutritionists and 2 students.
Language	English	Course in French but modules in French and English	English	English	English	English	English
Modules used	Modules 1-4.c and 5 by all participants. Modules 4.d and 6 only by chemists.	Modules 1-10, 12 out of which only modules 5, 6, 12 were in French.	Modules 1-10, 12	Modules 4.a-4.c entirely. Part of module 2, 10.b.	Modules 1-3, 4.b, 4.c, 7, 8, 10, 11	Each person evaluated one to three modules	All modules, but mostly 4.b- 4.d, 8, 10, 12

(Table 1 continued)

<table>
<tr><th></th><th>Food composition course in Iran (2008)</th><th>Course on food composition and biodiversity in Benin (2009)</th><th>Course on food composition and biodiversity in Ghana (2009)</th><th>University of Vienna as classroom course (2008)</th><th>University of Vienna as distance learning course (2009)</th><th>Self-learners and reviewers working in food composition area (2007-9)</th><th>Self-learners with little or no previous knowledge in food composition (2009)</th></tr>
<tr><td rowspan="2">Modality of usage</td><td>No module was sent before.</td><td>Participants received 10 modules 2 weeks before the course to complete them.</td><td>Participants received 8 modules 4 weeks* before the course to complete them.</td><td rowspan="2">Parts of the modules were used as exercises during the course, and modules 4.a-4.c were given as homework and answers were discussed the next morning.

All lectures were immediately followed by a practical exercise, including from modules.

Answers were not available to participants.

Initial and final tests were a subset of questions from the modules used.</td><td rowspan="2">Students completed the modules alone (over 55 hours) and evaluated themselves.

During the 1 day seminar, student's queries were clarified and a summary of important issues of each module was elaborated. Module 10.b was used to exercise food matching and compilation.

Final test was a subset of questions from the modules used.</td><td rowspan="2">Each person completed the assigned module and gave feed-back on understanding, completeness, and correctness, and provided suggestions for improvements.</td><td rowspan="2">Individuals completed modules, evaluated themselves and discussed with supervisor eventual questions. Then they compiled data, calculated recipes, worked on biodiversity, or used food composition data for their thesis.</td></tr>
<tr><td colspan="3">Participants completed the modules in 8 sessions after the corresponding lectures using hand-outs of the lectures and Greenfield and Southgate (2003). In an established order, each participant presented the answer to one question, which was then discussed by the whole group.

Correct answers to the modules were not available to participants.

Final test was a subset of questions from the modules used.</td></tr>
<tr><td>Evaluation by users</td><td>Useful to understand content of course but more time is needed.</td><td>Appreciated modules which generated discussions and allowed them to review and deepen knowledge from lectures, and to apply the new knowledge.

Useful to evaluate remaining knowledge gaps.

More time necessary for modules during the course. They should be sent 1 month before the course to participants.

Modules should all be in French.</td><td>Backbone of the course.

They stimulated discussion on the issues which helped understanding and comprehension.

Appreciated the exercises which allowed applying the new knowledge.

Useful to evaluate remaining knowledge gaps.</td><td>Heavy burden as homework but permitted to note that course content was understood.</td><td>Self-learning represented heavy burden. More time was needed than indicated, especially for exercises and reading (course material was in English and most students were German mother tongue).

Students found the 1 day revision essential to digest and collate the acquired knowledge from the different modules.

The interest of some modules was understood when completing the compilation module.</td><td>Provided suggestions for improvement and found in general that modules are comprehensive, well designed and systematic, and of high quality even though difficult for new learners.

Reading material sometimes difficult to follow and to locate information.</td><td>Useful to complete tasks.

More time needed than indicated and some questions and exercises were difficult.

The interest of some modules was fully appreciated when compiling data.

The biodiversity module gives a good overview on the topic.

It was good to work in pairs as eventual queries could be discussed.</td></tr>
</table>

(Table 1 continued)

	Food composition course in Iran (2008)	Course on food composition and biodiversity in Benin (2009)	Course on food composition and biodiversity in Ghana (2009)	University of Vienna as classroom course (2008)	University of Vienna as distance learning course (2009)	Self-learners and reviewers working in food composition area (2007-9)	Self-learners with little or no previous knowledge in food composition (2009)
Assessment of users' knowledge and skills acquisition	All participants passed the final test (60-95%).			Very significant improvement (on average 2.8 marks) between initial and final test. All students passed, mostly with A and B marks.	All students passed with A and B marks.	Not applicable	They performed well the assigned tasks without much of supervision time.
Lessons learnt	Modules can successfully be used in conjunction with food composition courses. More time is needed for participants to complete the modules. It would be useful to send the modules to the students well before the course. Modules are useful to prepare lectures.	Students do not complete modules before the course if only asked to do so. They should agree in writing. More time is needed for participants to complete the modules, if not done beforehand. Modules should be available in language of learners. Discussion of answers and table-round answering kept participants' attention and motivation high and allowed to comprehend course content.	Even though participants agreed to complete all modules half completed 60-80% and the other half 10-40%. Better to accept participants after passing initial test. In general, those who completed the modules before the course profited well from the course and had better results in the final test. Modules allowed less experienced lectures to run the course almost independently and to develop the final test.	Excellent course outline that each lecture is followed by a practical exercise, including from modules. Modules are useful as exercises and deepening of knowledge of corresponding lecture in a classroom-based seminar in a university setting. Modules procure self-confidence. Students have excellent motivation and capacity to learn and apply. Course should be extended to 4 days and final test on day 5.	Modules can successfully be used in as distance learning course in a university setting, especially if additional personal interaction/feed-back is provided. A one day revision seems essential or a regular contact with students over e-mail or internet. None-English mother tongue learners need significantly more time to complete modules. Students should have a deeper and larger understanding of food composition use and compilation as compared to a 3-days seminar but spend significantly more time.	Peer review and field testing are essential to obtain a good product. Suggested improvements were incorporated. Most of the available reading material cannot be changed by FAO/INFOODS but some new ones could be developed in the future and/or more summarizing PowerPoint presentations could be published.	Effective means of knowledge transfer on food composition and food biodiversity. Summarize and highlight main facts. Safes time for supervision and training. Profitable to work in pairs.

* 2 participants received the modules only few days before arrival because of late acceptance to the course.
ECTS = European Credit Transfer and Accumulation System

Annex 5

Submitted article: Charrondiere, U.R. and Burlingame, B. (2010). Report on the FAO/INFOODS Compilation Tool: a simple system to manage food composition data

Keywords: Food composition, compilation tool, standardized documentation, recipe calculation, INFOODS

Abstract
The need for a food composition database management system (FCDBMS) has been recognized since the beginning of database software development. Several attempts were made in the past to develop a FCDBMS for international use without general success. Many countries, especially developing countries, do not have the financial means to develop their own FCDBMS software. Therefore, FAO and the International Network of Food Data Systems (INFOODS) developed the Compilation Tool in Excel using internationally recognized standards and guidelines such as the INFOODS component identifiers; database stage separation; and INFOODS interchange guidelines of 2004. It also includes three recipe calculation methods based on yield and nutrient retention factors. It is the first publically available compilation tool allowing standardized compilation, documentation and management of food composition data , which can be tailored to individual needs. It has already been used successfully in different settings, e.g. to compile national food composition databases and biodiversity databases. However, the use of Excel spreadsheets is more prone to errors compared to database management systems. Despite these limitations, it is expected that the Compilation Tool will enable users, especially in developing countries, to compile and publish food composition databases with comprehensive documentation. In the future, it is hoped that a database management system with similar features will be developed and made freely and widely available.

1. Introduction
Early food composition data existed only on paper and their documentation, if available, was stored as paper archives which were not always readily accessible to successive compilers. When computers became more common, about 20 to 30 years ago, compilers expressed their need for a food composition database management system (FCDBMS) which would assist them to store, document and manage food composition data electronically in a standardized manner, and from which they could extract data for publication of user databases or tables. Even in the early days, it was recognized that an internationally available FCDBMS incorporating international standards, would assist countries to compile and document data in a harmonized manner (Southgate and Greenfield, 1988).

The first international standards were the INFOODS component identifiers (Klensin *et al.,* 1989), followed by an INFOODS proposition of food nomenclature (Truswell *et al.,* 1991; Pennington, 1996; Pennington *et al.,* 1995); and by INFOODS guidelines on data interchange (Klensin, 1992). INFOODS standards continued to be developed over time (INFOODS, 1995, 2004, 2010b), as were other international standards, usually building on the work of INFOODS: components by EUROFOODS (Schlotke *et al.,* 2000) and European Food Information Resource Network (EuroFIR) (Møller *et al.,* 2008a), food nomenclature (LanguaL, 2010); guidelines on interchange and database management and transport package by NORFOODS (Møller, 1992); CEECFOODS (ALIMENTA, 2010), EUROFOODS (Schlotke *et al.,* 2000), INFOODS/FAO (FAO, 2004 a), or EuroFIR (Møller *et al.,* 2008 b,c).

Over the last 20 years, several FCDBMS have been developed by national compilers such as USDA (2010), most European countries (EuroFIR, 2010), New Zealand (Burlingame et al., 1992). In addition, FCDMS systems have been developed for regional use (ALIMENTA, 2010), for specific projects such as EPIC (Vignat *et al.,* 2001), as commercial databases for different professions such as for clinical dietitians (CBORD, 2010), for the food industry (e.g. Nestle or Unilever), and for food labelling purposes (FSANZ, 2010). Several attempts were made in the past to develop a FCDBMS for international use such as the European Nutrition Information Management System EuroNIMS (Arnouts, 1996; Becker & Unwin, 1995), CERES (FAO, 2004 b) or the German platform (Hartmann *et al*., 2008),. Each had limitations and none of them achieved wide use, while others only proposed transport packages from one existing FCDBMS to another (Møller *et al.,* 2008 b,c). Another attempt is underway to develop a global FCDBS based on EuroFIR standards (FoodCase, 2010).

Many countries, especially developing countries, often do not have the financial means to develop their own FCDBMS software. Without such a system, however, it is difficult or impossible to carry out the fundamental tasks of standardized data storage, management and documentation. For this reason, many countries do not compile and publish a national food composition database.

When FAO recently assisted countries (e.g. Lesotho and Armenia) in developing their national food composition database, the lack of a FCDBMS became so important that the authors started to build a simple Excel file to compile a national database. Over time, this file became more sophisticated with more possibilities of documentation. And finally, when the Food Composition Study Guide (Charrondiere *et al.,* 2009a, b) was developed, a freely accessible tool was needed for learners to practise compilation, documentation and recipe calculations. This led to the development of the current Compilation Tool version 1.2.1, which is available on the INFOODS website, free of charge.
This paper describes the Compilation Tool, the standards and guidelines used, and the experience in its use.

2. Material and methods

A comprehensive analysis of all relevant technical standards was undertaken in the fields of food and component nomenclature, food composition database management, data interchange and data presentation. This review included standards from INFOODS and its regional data centres (LATINFOODS, EUROFOODS, CEECFOODS, ASEANFOODS), EuroFIR, Codex Alimentarius, IUPAC, AgMES metadata elements (FAO, 2010), and ISO. The investigation assisted in deciding which standards and formats were the most suitable for the Compilation Tool. The Compilation Tool version 1.2.1 with its users' guidelines can be accessed from the INFOODS website (INFOODS, 2010 a).

The Compilation tool has been used in different settings in conjuction with the Food Composition Study Guide (Charrondiere et al., 2010), at FAO, Rome, and in different countries (Armenia, Lesotho and Cameroon).

3. Results and discussion

3.1 Overview and objectives of the Compilation Tool

The Compilation Tool was developed by FAO/INFOODS to allow users to compile, document and manage a food composition database according to internationally recognized recommendations and standards. In addition, compilers should be able to calculate nutrient values of recipes using any of the existing three recipe calculation systems with any set of nutrient retention factors at food group level and any yield factors.

For the moment, 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.

3.2 Choice of standards and format

The investigation showed that there are existing relevant technical standards which can either be used directly or could be mapped to the features used in the Compilation Tool. It was decided to use INFOODS standards, which were developed through extensive collaboration taking existing international standards into account (e.g., International Union of Pure and Applied Chemistry (IUPAC)). *Table 1* summarizes the available international standards and indicates which were used in the Compilation Tool.

The objective of the Compilation Tool was to keep it as simple as possible to allow a wide range of users, including those with little database experience, to compile food composition data. Therefore, the Compilation Tool was developed in Excel because of its widespread availability and familiarity to users, and because Windows 2008 (Vista) allows data export in XML (Extensible Markup Language). However, the authors are aware that there are a number of pitfalls in the choice of Excel, as it is prone to errors and complicated when documenting data through several linked spreadsheets. Open source software products such as MySQL (2010), which are multi-platform relational database management systems, are being considered for future development.

The component identifiers available from INFOODS (Klensin *et al.,* 1989; INFOODS, 2010 b) and EuroFIR (Møller *et al.,* 2008a) are similar and the EuroFIR component names are built on the INFOODS component identifiers (also called tagnames). During a technical meeting between INFOODS and EuroFIR (INFOODS, 2010 c) in 2009, many component identifiers were harmonized and only few differences remain. Those differences include fatty acids, but more importantly, the EuroFIR component system does not differentiate disperate components due to method or data expression (e.g. as dietary fibre, carbohydrates, or folate), which result in different nutrient values which need to be reported separately (Charrondiere and Burlingame, 2007). In addition, the INFOODS system has been stable over time, while new tagnames are being added, whereas the EuroFIR thesaurus on components was not yet finalized when the Compilation Tool was developed. Thus, the INFOODS component identifiers have been used for the Compilation Tool.

The food nomenclature is neither based on the original INFOODS (Truswell et al., 1991) or LanguaL (2010) recommendations, as they would increase the size of the Excel file enormously which would render the file user unfriendly. In the case of LanguaL (2010) the LanguaL Food Product Indexer software is required, adding another level of complexity. Therefore it was decided to simply propose three name fields (i.e. food name in own language, food name in English, and scientific name) with the recommendation to include all necessary food descriptors in the food name such as cooking method, part, origin, preparation/processing method, preservation method, maturity, grade, physical state, colour, other descriptors.

It was decided to structure the Compilation Tool according to Greenfield & Southgate (2003) and separate the database into different stages: archival, reference and user databases. This separation into different stages will assist the compiler in differentiating the tasks to be done in each database. For example, to compile original data into the archival database; to manage data in the reference database while completing missing data through calculation or estimating; or to select a subset of the reference database to be published in the user database.

For the documentation of the data, the INFOODS, EUROFOODS, ALIMENTA and EuroFIR guidelines on interchange and database management and transport package were examined (Klensin, 1992; Schlotke *et al.,* 2000; FAO, 2004 a; Møller *et al.,* 2008 b,c; ALIMENTA, 2010). The main fields for data documentation are similar in all the examined documents. However, the ways in which they are named, expressed or used are different. It was decided to base the Compilation Tool on the INFOODS Standards for food composition data interchange (FAO, 2004 a) because they also present guidelines on how to construct a FCDBMS and because they are consistent with other INFOODS standards. However, in some cases, fields were moved or deleted in accordance with experiences (see section 3.3 for more information).

For the recipe calculation, three calculation systems exist (i.e. the recipe method, ingredient method and mixed method) and any of the three can be used, even though the mixed and recipe method give more similar results (Charrondiere *et al.,* 2009).

From the existing sets of nutrient retention factors (Bergström, 1994; McCance & Widdowson's, 2002; USDA, 2003; Bognár, 2002; Vásquez-Caicedo *et al*., 2007), it was decided to incorporate those of McCance & Widdowson's (2002) which were complemented by those of Bognár (2002), because they are on food group level, they are complete for all food groups, and they are already widely used.

3.3 Description of the different spreadsheets of the Compilation Tool
The Compilation Tool has 11 worksheets which are described in detail in the published Guidelines for the use of the Compilation Tool (INFOODS, 2010 a): Codes, Archival database, Reference database, Recipe + ingredients, Recipe calculation, User database, Component, Bibliography, Value documentation, Sampling, and Methods.

The **'Codes' worksheet** lists the codes used in the different worksheets to indicate progress or to document the data at different stages of the compilation. The **'Archival database' worksheet** should hold only original data as provided in the original data source (Greenfield & Southgate, 2003). The only exception is the adaptation of units and denominator to those in the Compilation Tool, as it is difficult in Excel to hold several units and denominators for the same component. The Compilation Tool does not include any pre-defined food grouping or food coding system. The user will, therefore, have to decide on a food classification and coding system and apply it. The Compilation Tool does not have the possibility to automatically attribute food codes.

In the **'Reference database' worksheet**, the data can be aggregated, calculated, imputed, copied, or estimated (Greenfield & Southgate, 2003) and each new data entry (value or record) can be documented (i.e. at food level in the pre-defined fields or at values level in a line to be inserted below the line with the values). For components for which values are always calculated in the database (e.g. energy) or for which several INFOODS components identifiers exist (e.g. dietary fibre, carbohydrates or some vitamins) 'standardized' components have been added to the Compilation Tool. These fields allow compilers to enter their formula with specific conversion factors and to calculate all values in the same manner; and they provide the field to indicate the most appropriate value among different data expressions and methods to be published in the user database. Users can change the pre-selected choices for these 'standardized' components; e.g. for carbohydrates, they can select 'available carbohydrates by summation' instead of the pre-selected 'available carbohydrates by difference' which was assumed to be the expression that most compilers in developing countries would use because very little data exist for available carbohydrates by analysis (FAO, 2003). In the reference database, two fields with formulas are available to check data integrity: 'sum proximates (original)' and 'sum of proximates (own DB)' The comparison of both sums might provide explanations of why certain values are different between the original source and the values in the own database. The expected sum of proximates should be 100 +/- 3 (Greenfield & Southgate, 2003). The **'User database' worksheet** is empty and users need to decide upon the format and which foods and components will be selected from the reference database and be published in the user database.

As recipe calculations can be an important part of compilation, and tools are needed to calculate them in a standardized way, the Compilation Tool comprises two worksheets for recipes: the 'recipe + ingredient' and 'recipe calculation' worksheets. In the **'Recipe + ingredient' worksheet**, all recipes with their ingredients and quantities should be entered, together with the yield factors (i.e., to account for water loss or gain) and a brief description of the preparation (e.g. cooking method). This information should be published in the user database or table. In case the gram amount of each ingredient is not known, formulas are entered in specific fields to calculate in a standardized manner the edible portion of each ingredient in grams if the necessary information is known, e.g. weight of unit or household measure for the ingredient. The rounded quantity of each ingredient is then used in the 'recipe calculation' worksheet. The **'Recipe calculation' worksheet** contains the same components in the same order as in the archival and reference databases. In this worksheet, the field 'priorityclass' (as used in the archival and reference databases) has been replaced by 'quantity of ingredient in g/ yield factor' to enter the gram amount of the ingredients and the yield factors. Yield factors, either measured or estimated from literature sources (e.g. Bergström, 1994), need to be entered. The yield and nutrient retention factors are used in the formula of the three recipe calculation systems. The users can change the pre-entered values of the nutrient retention factors or add values for other cooking methods according to their needs, and document the sources of the new values.

The **'Component' worksheet** contains the list of all components included, together with their INFOODS component tagnames (Klensin et al. 1989; INFOODS, 2010b), the component name, units (denominator is per 100 g edible portion), definition, comment and maximal number of decimal places. The **'Bibliography' worksheet** contains bibliographic references used in the database. The different field names are derived from the INFOODS Standards for food composition data interchange (FAO, 2004 a) and are based on AgMES metadata elements (FAO, 2010). Users have two possibilities to enter references: either to enter the specific information into the corresponding fields or to enter all information about the source into the 'consolidated' data field.

The '**Value documentation**' **worksheet** allows users to document the nutrient values in the reference database according to FAO recommendations (2004 a). However, the fields 'dates of analysis', 'sample preparation', 'limit of detection (LOD)' and 'limit of quantitation (LOQ)' were moved from the Method to value documentation, and a field for 'QC (quality control) in the laboratory' was added. The **'Sampling' and 'Method' worksheets** allow users to document the sampling procedures and relevant analytical method information for the nutrient values in the reference database according to INFOODS standards (FAO, 2004 a). In the Method worksheet, the componentid, LOD and LOQ were removed, and instead of including the bibliographic reference for the modification, the method code for each analytical step is requested (preparation, separation and quantification).

3.3 Application of the Compilation Tool

Experience showed that the Compilation Tool can be used by a wide range of users in different settings, including those with initial limited knowledge of Excel. Most needed a re-enforcement of their knowledge on INFOODS component identifiers. The Compilation Tool was mainly used in training and by self-learners, but also by national compilers, and often in conjunction with the Food Composition Study Guide (Charrondiere *et al.,* 2009a,b) which contains exercises on the compilation, documentation and recipe and other calculations to be carried out with the Compilation Tool.

The Compilation Tool was used in five postgraduate training courses (India, Iran, Benin, Ghana, and Wageningen) and in two courses at the University of Vienna on food composition. Participants were able to practise component identification, component matching between different sources, compilation of data from food composition databases and recipe calculation. With this exercise, they noticed the importance of the previously acquired knowledge on component identification, documentation, food identification and nomenclature.

The Compilation Tool was also used to compile national databases in Lesotho (Lephole et al., 2006), Armenia (Babikyan et al., 2010) and in Cameroon (ongoing project); and to compile the Food Composition Database for Biodiversity with data on milk from over 300 minor dairy animal breeds, 450 fruits and vegetables varieties, and about 1000 potato varieties. This database contains data with their bibliographic reference and is freely accessible (INFOODS, 2010 d) and was compiled within the project to collect and report data for the Nutrition Indicator for Biodiversity on food composition (FAO, 2008). The ongoing project of ECOWAS, Bioversity International and FAO also uses the Compilation Tool to collect in a harmonized way food composition data from five West African countries (ECOWAS, unpublished). Charrondiere *et al.* (2009) used the Compilation Tool to calculate the nutrient values of seven recipes to investigate if differences in nutrient values are due to nutrient retention factors or calculation systems (ingredient, recipe and mixed method).

The Compilation Tool has been adapted to the users' needs. For example, for the work on recipes, two different sets of nutrient retention factors (Bergström, 1994; Bognár, 2002) were added. For the Food Composition Database for Biodiversity some fields were replaced with those of relevance for biodiversity, such as 'country', 'season' or 'type of biodiversity category (variety, cultivar, breed, underutilized)'. In addition, some components were added to the pre-entered list of components (e.g., fatty acids, bioactive non-nutrient phytochemicals), and entire spreadsheets were added with different denominators, e.g., 'per 100 g dry matter' or 'per 100 g total fatty acids', because many references did not report water or fat values which would have allowed conversion to 'per 100 g edible food'.

As the Compilation Tool is a simple tool without any automatic controls in data entering, errors can be easily introduced. For example, when adding components some compilers deleted parts of formulas or assigned them to the wrong data fields (when introducing new data columns, rows or fields), or they entered new components only in the archival database and forgot to enter them into the reference database. Others did not pay attention to the differences in units and the denominator between those in the Compilation Tool and the source of data (e.g. in the scientific article or food composition database).

4. Conclusions

The Compilation Tool is expected to be most useful in developing countries, as experience has already shown. The successful use of the Compilation Tool and its combination with the Food Composition Study Guide (Charrondiere *et al.,* 2009 a,b) is expected to enhance the development and publication of more national and regional food composition tables and databases. It is recognized that the Compilation Tool has drawbacks and needs to be improved, and it is hoped that it will be replaced in the future by a more sophisticated food composition database management system, which will also be free of charge and available globally.

Acknowledgement
The authors acknowledge the contribution of the INFOODS listserv mailing list and Annalisa Sivieri for their suggestions for improvements of the Compilation Tool.

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Table 1 Relevant international standards and guidelines and their use in the Compilation Tool

	Food nomenclature	Component nomenclature	Database management	Interchange	Data presentation
INFOODS	mappable	Yes	Yes	Yes	N/A
EuroFIR	mappable	mappable	N/A	mappable	N/A
ISO	N/A	N/A	N/A	N/A	Yes (e.g. date)
Codex Alimentarius	mappable	N/A	N/A	N/A	N/A
IUPAC	N/A	Yes, when available	N/A	N/A	N/A
AgMes	N/A	N/A	N/A	N/A	Yes (bibliographic data)
Taxonomic standards	Yes	N/A	N/A	Yes	Yes

Annex 6

FAO Publication: Charrondiere, U.R., Burlingame, B., Berman, S., Elmadfa, I. (2009). Food Composition Study Guide. Questions and exercises - Volume 1.

Only module 1 is included for demonstration purposes.

The entire document 'Food Composition Study Guide. Questions and exercises - Volume 1' is found at http://www.fao.org/infoods/publications_en.stm

Module 1

BASIC PRINCIPLES OF A FOOD COMPOSITION PROGRAMME

LEARNING OBJECTIVES

By the end of this module the student will be able to:

- understand the objectives of food composition databases;
- run a food composition programme (including budget considerations);
- involve users, compilers and analysts in food composition programmes;
- collaborate internationally;
- know how to obtain food composition data.

REQUIRED READING

- **Charrondiere, U.R**. 'Basic principles for assembling, managing and updating food composition databases', available at: http://www.fao.org/infoods/presentations_en.stm

and if possible:

- **Greenfield, H. & Southgate, D.A.T.** 2003. Food composition data – production, management and use. *FAO, Rome*[1]. Introduction and chapters 1–2 (pp. 5–31). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf

RELEVANCE FOR DIFFERENT GROUPS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts ++

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1-4 hours
- Answering the questions: 1-2 hours
- Completing the exercises: 1-2 hours

[1] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to the PDF file.

Questions

I.Q1 Indicate the correct reasons for compiling and publishing food composition tables and databases. Select True or False. *(4 points: ½ point for each correct response)*

Reasons for compiling and publishing food composition tables and databases:	**True**	**False**
to analyse nutrient intakes or develop nutrient requirements.		
to compare food intakes and relate them to disease outcome.		
to carry out epidemiological research on the relationship between nutrient intake and disease.		
to produce food labels.		
to develop new analytical methods.		
to formulate institutional and therapeutic diets and plan menus.		
to promote nutritionally-important plants and animals to improve health or for breeding programmes.		
to inform consumers about good food choices.		

I.Q2 Before food composition data can be published, a compiler needs to collect the data and manage them systematically. Match the four levels of database management first to their corresponding definition and then to the tasks to be performed by a compiler. *(6.5 points: ½ point for each correct response)*

Levels of database management:
1. Data sources
2. Archival database
3. Reference database
4. User database

Definition	**Levels**
Collection of data that have been scrutinized, standardized, aggregated and completed.	
Collection in paper or electronic form of published and unpublished literature containing analytical and other compositional data.	
A subset of the reference database disseminated to the public in different formats: simplified (also called abbreviated or concise), comprehensive (also called unabridged), or special purpose tables and databases.	
Collection of records holding the original data of the collected literature in electronic format.	

Tasks to be carried out related to different levels of database management	Levels
Update protocols on evaluating, calculating, editing, combining and averaging data	
Prepare and disseminate different user tables and databases, depending on specific needs	
Scrutinize (= evaluate) data to obtain good-quality and representative data	
Assign specific and unique food codes to each food in the database to allow for their retrieval and management within the databases and ensure the traceability of their component values	
For users, include concise information on methods, sampling and calculation procedures, nutrient definitions, quality index and literature sources	
Compile the collected data and metadata into a computerized format and enter all bibliographic references	
Standardize units and express all nutrients and other components in a uniform manner	
Collect documents and data files with published and unpublished data	
Add data (borrowed, calculated, imputed) and document all data sources	

* Both are possible because most food records are created in the archival database and some in the reference database.

I.Q3 List in the correct order the tasks to be undertaken by a newly appointed food composition compiler involved in developing a food composition programme. The plan calls for a database of 400 foods including 20 analysed foods. Start with 1 for the first task and end with 7 for the last. *(3.5 points: ½ point for each correct response)*

Tasks of a food composition compiler	Order of tasks
- Select foods and nutrients	
- Collect recipes, including ingredients - Compile recipes in the reference database	
- Develop guidelines for disseminating data to users (e.g. commercial user, research institutes, others) and corresponding costs - Prepare and disseminate user food composition tables and databases	
- Review, collect and compile existing information into an archival database - Develop (or provide input for) sampling plans and analytical programmes, supervise the analytical programme and evaluate analytical reports	
- Create a steering committee with stakeholders and users - Obtain training in food composition, e.g. distance learning and/or classroom course - Network with compilers, analysts and users from other countries and with international networks or organizations (e.g. INFOODS Regional Data Centres) - Prepare a budget proposal, and approach potential donors - Obtain information on users' needs	
- Maintain and update the database continuously	
- Start compiling foods in the reference database - Obtain refresher training in food composition, e.g. classroom course, study tour and/or distance learning - Incorporate the analytical data into the reference database	

I.Q4 Before starting a national food composition programme, it is highly recommended that steps be taken to ascertain whether another institution or governmental organization is mandated to undertake food composition-related activities. If this is not the case, authorization should be sought from the appropriate government agency (e.g. agriculture, health) to act as coordinator of the national food composition programme.

Which of the following statements are reasons for obtaining such authorization? Select True or False. *(2.5 points: ½ point for each correct response)*

Reasons for obtaining authorization	**True**	**False**
Such authorization may prevent another food composition table being published, with the claim that it is the authoritative (official) table for the country in question.		
Such authorization may prevent other food composition tables being published in the same country.		
Such authorization might result in a budget allocation from the government or other potential donors, both within and outside the country, for the organization to develop, update and maintain a food composition programme.		
Such authorization might result in allocated staff time to develop, update and maintain a food composition programme – meaning that food composition work will not be done on a voluntary basis as and when time permits, but as part of the work plan and programmed outputs.		
Such authorization charges the organization with developing, updating and maintaining a food composition programme.		

I.Q5 Why is it important for food composition data compilers, food analysts and users to interact through national and international networks? Select True or False. *(3 points: ½ point for each correct response)*

Analysts, compilers and users should collaborate, both nationally and internationally, to develop a food composition database that:	**True**	**False**
meets the needs of a variety of users because it contains most foods (including foods in the different states in which they are consumed, i.e. 'foods as consumed') and nutrients required by the different users.		
is relevant and practical, and presented in a user-friendly format.		
is of the highest possible quality, provides updated data and is internationally compatible.		
is compiled in accordance with ad hoc[2] procedures developed by the compiler, analysts and users.		
is compiled in accordance with national and international standards for data generation, compilation and management.		
may be used without verification in other countries.		

I.Q6 Indicate the difference between a typical food composition table and a food composition database. Put 1 for 'food composition tables' or 2 for 'food composition databases', or both. *(4 points: ½ point for each correct response)*

Answer (see also Greenfield & Southgate, 2003, pp. 2, 10):

Differences between food composition tables and databases	
Two-dimensional	
Multidimensional	
Includes comprehensive documentation	
Includes little or no documentation	
Intended for users	
Printed	
Computerized	
Includes archival data, source data, calculations, etc.	

2 Only for the specific purpose, case or situation at hand, and not validated.

I.Q7 Indicate the statements describing a user food composition database which is well-designed and comprehensive. Select True or False. *(7.5 points: ½ point for each correct response)*

Statements describing a well-designed comprehensive user food composition database	**True**	**False**
Data should be representative of the foods consumed.		
Analytical data should be of sound quality.		
It is often better to calculate data than to have missing data.		
Coverage of key foods and core nutrients should be as complete as possible.		
For all users, it is sufficient to include only raw food.		
Nutrient values should be limited to those for which analytical data are available.		
Units of the same nutrients should depend on the concentration in the food, i.e. in g, mg or mcg, depending on the food in question.		
Food descriptions are optional.		
Scientific names help identify the food. Food descriptions should be clear.		
Data should be consistently and unambiguously expressed .		
Metadata should be provided at nutrient value level for advanced users, e.g. researchers, manufacturers.		
Data sources should be stated only in the introduction.		
Tables and databases should be easy to use.		
The different user databases should be compatible.		
For nutritional epidemiological studies, it is better to have missing data that are treated as zero than to have unreliable data.		

I.Q8 Plain figures of nutrient values are not meaningful as such; they must be accompanied by the food name and descriptors, the component name and definition, and unit and denominators. In order to facilitate the understanding, use and management of food composition data, the data must also be sufficiently documented with additional metadata, i.e. data about data. Food composition metadata include information on the source and the compositional value: Source description (includes all information needed to identify the origin of the food composition data, e.g. laboratory, literature, etc.), sample descriptions and procedures (which are needed to judge the representativity of the foods); food classification, agricultural production and storage conditions, preservation and cooking methods, food additives or fortificants, value descriptions (include information on source of the value), analytical methods used, uncertainty and specificities of the methods, and statistical description of the analytical data.

Which of the following data are considered either to be food composition data or related metadata? Indicate the correct responses with 'x'. *(5 points: ½ point for each correct response)*

Data	**Food composition data/ metadata**
Component values	
Component name and definition	
Food name and description	
Sampling	
Source of data	
Unit and denominator	
Method information	
Statistical information of component values	
Food groups	
Information about calculation, including recipes	

I.Q9 Give five reasons why it is necessary to continuously update and maintain a food composition database. *(5 points: 1 point for each correct response)*

1.

2.

3.

4.

5.

I.Q10 Many food composition databases and tables are protected by copyright. This measure is intended to protect intellectual property and prevent unwanted use of data. Hence, users are sometimes required to pay a royalty fee. Select the statements that indicate the consequences of copyright protection for compilers and users. *(3 points: ½ point for each correct response)*

Consequences of strict copyright protection for compilers and users	True	False
Compilers have regularly taken legal action against persons using their data without prior permission.		
Compilers may impose acknowledgement of the data source.		
Compilers derive most of the budget for their food composition programme from royalty fees.		
Users do not have free access to the data and cannot use the data they need, unless they pay the fees.		
Some users argue that fees for food composition data should be eliminated or reduced. This is because, in most cases, public funds are used to compile the data and because all food composition databases include data borrowed free-of-charge and sometimes without authorization from scientific and other literature.		
Interchange of food composition data is enhanced by copyright.		

I.Q11 List three weak points inherent in food composition data when used to calculate nutrient intake estimations. *(3 points: 1 point for each correct response)*

1.

2.

3.

SAMPLE ANSWERS TO THE EXERCISES

I.E1 A compiler has obtained US$200,000 from the government to develop, within a period of two years, the first national food composition programme. The food composition database should contain at least 400 foods. Twenty foods representing the main contributors to nutrient intake estimations should be analysed. Draw up a budget by choosing from the following elements. No amount may be changed. *(15 points)*

Elements to draw up a budget	US$
Salary per compiler per year (producing data for 200 calculated/ borrowed foods **OR** for 20 analysed foods)	20,000
Cost per food analysis if outsourced and analysed in duplicate: - of main nutrients (macronutrients, minerals, selected vitamins) - of macronutrients (water, ash, AOAC dietary fibre, protein, fat, ash) - of fatty acid profile - of amino acid profile - of minerals (ICP method for 22 elements) - per vitamin	 1,000 300 150 100 200 100
Sampling cost for all food samples for one food (including collection, purchase and transportation of several representative samples of each food collected in accordance with the sampling plan)	500
Running costs of a laboratory per year (rental, salaries, chemicals, etc.)	40,000
Purchase of essential laboratory equipment	100,000
Purchase of computer and basic software	3,000
Cost of food composition database management system	10,000
Cost of purchasing other food composition databases and tables	1,000
Expert consultant costs per week	1,000
Cost of one meeting with steering committee	500
Publication costs (printing of 1,000 copies, website dissemination)	3,000
Cost of meeting to launch user database	1,000
Cost of participating in the International Food Data Conference	2,000
Cost of participating in a regional INFOODS meeting	1,000
Cost per participant in food composition course	5,000
Use of distance learning tool *Food Composition Study Guide* to increase knowledge on food composition	0
Annual running costs (telephone, photocopying, electricity, office administration, etc.)	5,000
Possible income	
Price per printed food composition table	20

It might be useful to redo this exercise after completion of all modules.

I.E2 The compiler realizes that the US$200,000 provided by the government is not enough to complete the food composition database. List two options for the compiler to obtain more funding. *(2 points: 1 point for each correct response)*

1.

2.

I.E3 One member of the food composition programme steering committee is the most famous nutrition researcher in the country. She has recently undertaken a food consumption survey based on 24-hour-recalls, and brings a list with 1,000 foods to be included in the food composition table, including numerous recipes, prepared foods and brand name foods. Originally, the compiler thought of including only raw foods in the database and no brand name or prepared foods. List two arguments by the researcher for including raw, cooked and brand name foods and two arguments by the compiler for including only raw foods. *(4 points: 1 point for each correct response)*

For inclusion of raw foods only

1.

2.

For inclusion of raw, cooked and brandname foods

1.

2.

Annex 7

FAO Publication: Charrondiere, U.R., Burlingame, B., Berman S, Elmadfa I. (2009). Food Composition Study Guide. Questions, exercises and answers - Volume 2. The revised version of 2010 is included in the annex.

The entire document 'Food Composition Study Guide. Questions, exercises and answers - Volume 2' is found at http://www.fao.org/infoods/publications_en.stm

Vol. 2

Food composition study guide

Questions and exercises & answers

INFOODS

FIAT PANIS

Food composition study guide

Questions and exercises & answers

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Barbara Burlingame
Sally Berman
Ibrahim Elmadfa

THE INTERNATIONAL NETWORK OF FOOD DATA SYSTEMS

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2009

Revised version

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ISBN 978-92-5-106540-2

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FOREWORD

In the 1930s and 1940s, as the individual B vitamins were being discovered, there was a demand for knowledge of their content in foods. FAO began compiling Regional Food Tables using the limited existing data. In the 1940s, Food Analysis Institutes were established in Mexico, Cuba, Columbia and later Peru, with support from the Rockefeller Foundation, the Kellogg Foundation and US AID. The Institute of Nutrition of Central America and Panama (INCAP) was conceived originally as a Food Analysis Institute for Guatemala. Although its mission was broadened, analysis of Central American foods had a high priority and one of its first publications was a 'Food Composition Table for Central America and Panama', produced jointly with FAO.

However, in the decades that followed, funding and emphasis shifted more towards nutrition studies. Food analysis and nutrient data base compilation in developing countries became limited to a few under-funded laboratories. Available food composition data were increasingly outdated and based on obsolete methods. The irony of this was that, as the studies of human nutrition increased, so did the need for reliable food composition data. In 1973, a small group of internationally involved nutritionists became concerned about the growing obsolescence and inadequacy of available food composition data, especially in developing countries, and concluded that the situation had become urgent. For example, promising studies of diet and chronic diseases were invalid because of unreliable food composition data.

The group obtained administrative and financial support from the United Nations University, use of the Rockefeller Foundation Conference Center in Bellagio, Italy, as well as support from the US National Cancer Institute, United States Department of Agriculture, United States Food and Drug Administration and seven major food companies. In addition, FAO, World Health Organization (WHO), International Union of Nutritional Sciences (IUNS) and International Union of Food Science and Technology (IUFoST) were represented. The sponsorship was evidence of how important this issue had become.
The Bellagio meeting in 1983 proposed the formation of an International Network of Food Data Systems (INFOODS) to be administered by the United Nations University (UNU) in collaboration with FAO that would establish units for the promotion of an improved food composition database in every country and region, and that would make the best available food composition data freely accessible to nutrition and health workers in all developing countries. This would require a system of nomenclature for universal use and defining the specific content of an ideal data file.

With the collaboration of FAO and UNU this was achieved in a few years, a task made feasible by the unexpected rapid development of the Internet. The recommendation to establish a Journal of Food Composition and Analysis (JFCA) was fulfilled. Later, administrative responsibility for INFOODS and JFCA was also assumed by FAO since 1999. Training has not been neglected. The biennial training workshops at Wageningen University have played an important role as has the basic text book by Greenfield and Southgate (2003) *Food composition data – production, management and use.* Graduates of the Wageningen course have replicated it several times in most of the regions, but financial support for regional courses has been increasingly difficult to obtain.

It is now increasingly recognized that, while nutritional deficiencies remain important in some populations, nutrition is an important factor in essentially all infectious and chronic diseases in all populations. The more that is invested in finding out which nutrients and other ingredients of food are responsible, the more important reliable food composition databases become and the greater the need for well trained analysts and food database managers and users. This Food Composition Study Guide comes at an opportune time. Not only is the role of human nutrition in determining current and future health recognized more widely than ever before, but also distance-learning tools such as these are in increasing demand and, in some cases, replace classroom learning. It is an important contribution!

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President, International Nutrition Foundation
Institute Professor Emeritus. Massachusetts Institute of Technology

ACKNOWLEDGEMENTS

We are grateful to all those who contributed to the development of the Food Composition Study Guide, particularly to all peer reviewers (Gary Beecher, Eliana Bistrich Giuntini, Rakesh Bhardwaj, Carol Byrd-Bredbenner, Isabel Castanheira, Paolo Colombani, Roger Djoule, Marie Claude Dop, Lois Englberger, Nino dePablo, Jean Francois Hausman, David Haytowitz, Paul Hulshof, Venkatesh Iyenger, Kunchit Judprasong, Jehangir Khan Khali, John Klensin, Harriet Kuhnlein, T. Longvah, Alison Paul, Pamela Pehrsson, Jean Pennington, Janka Porubska, Prapasri Puwastien, Hettie Schönfeldt, Louwrens Smit, Ian Unwin, Ana Vasquez-Caicedo, Elizabete Wenzel), to those who contributed to its content (Marie Luccioni, Edouard Oddo, Enrica Biondi, Prapasri Puwastien) and those who tested the modules: George Annor, Rekia Belahsen, Natasha Danster, Heinz Freisling, Melanie Fröhler, Ingrid Führhacker, Verena Hasenegger, Sonja Kanzler, T. Longvah, Susanne Lüftenegger, Katharina Maierhofer, Elinor Medhammar, Beatrice Mouille, Emma Nilsson, Verena Nowak, Nino dePablo, Esther Sakyi-Dawson, Annalisa Sivieri, Francisca Smith, Renee Sobolewski, Barbara Stadlmayr, as well as the participants of the food composition courses in Bratislava, Slovak Republic (2008), Teheran, Iran (2008), Cotonou, Benin (2009) and Accra, Ghana (2009) and at the University of Vienna, Austria (2008, 2009).

We are also grateful to Oman Bolbol for the cover design and to Giuseppina Di Felice for the layout.

INTRODUCTION

Since the establishment of the International Network of Food Data Systems (INFOODS) in 1984, there has been a significant improvement in the quality and availability of food composition data worldwide. INFOODS has developed standards and guidelines for the collection, compilation and reporting of food composition data. The network collaborates in the dissemination of knowledge of food composition and standards through regional training courses on the production and management of food composition data. Classroom-based food composition training courses started in 1992. Since then, nine courses have been held in Wageningen, the Netherlands, and 13 courses in Africa, Asia, Latin America, Near East and Oceania. The courses are based on the book *Food composition data – production, management and use* by H. Greenfield and D.A.T. Southgate (2003), and comprise lectures, group work, practical sessions and field trips. Each course, consisting of 20–30 participants, lasts from two to three weeks, covers all relevant aspects of food composition, and targets professionals in food composition data generation, compilation and use – usually from fields such as nutrition science, food science, public health and analytical chemistry. These courses contribute to capacity-building and strengthening of food composition activities at national and regional levels; improving the availability, comparability and quality of food composition data; improving the adequate use of these data; and the training of trainers, which ultimately lead to improved quality and quantity of compositional data and result in e.g. better dietary assessments, policy decisions, food labels and consumer choice.

By the end of 2009, about 500 participants had attended these courses. In many cases, former participants have taken up key positions in their countries and regions in the implementation of food composition programmes and have become trainers in subsequent courses. Others have left the area of food composition. There are still many professionals who have never been trained in food composition and who are in need of this knowledge. In addition, the number of sectors needing food composition data is expanding to areas such as food biodiversity, plant breeding, dietary diversity, food industry and food regulation, to give just a few examples. There is, thus, an obvious and evident need to train more professionals in food composition worldwide and to introduce food composition into the curricula of future professionals, especially nutritionists, food technologists and dieticians However, courses in the classroom are expensive and time-consuming for both participants and organizers, and financial support for such activities is dwindling.

In line with the current trend whereby continuing education is no longer restricted to the classroom and professionals learn on the job using distance and e-learning tools, FAO and INFOODS developed the Food Composition Study Guide, a self-study version of the classroom course (Charrondiere *et al.,* 2009[1]).

One of the challenges in developing this Study Guide was to make it attractive and understandable for individuals from different educational backgrounds, to maintain student motivation and to encourage them to complete relevant modules. The Food Composition Study Guide is one of several initiatives which FAO will provide to encourage and promote continuing education in food composition activities.

AUDIENCE AND OBJECTIVES

The Food Composition Study Guide was developed to reach a wide audience and to make knowledge of food composition more accessible and less costly, especially for those not able to attend classroom courses. At the same time, the goal was to ensure that the quality of classroom course content would be maintained in the Food Composition Study Guide. It can be used for self-study, in a university setting or in conjunction with postgraduate food composition courses (e.g. at the end of sessions or of the course to evaluate learning, as a refresher after a course, or as a distance-learning tool). The Study Guide has successfully been implemented in all these settings.

The Study Guide is intended mostly for compilers and users of food composition data and also for analysts. The Study Guide is also designed to serve as a basis for master and PhD classes or as distance-learning packages at universities. Some universities have already shown interest in including it in their

[1] Charrondiere, U.R., Burlingame, B., Berman, S., Elmadfa, I. 2009. Food composition training: Distance learning as a new approach and comparison to courses in the classroom, Journal of Food Composition and Analysis 22, 421–432.

curricula. As the Study Guide covers all aspects of food composition it will enable students to assimilate all principles to generate, compile or use food composition data and to apply them correctly in their future work. The Study Guide does not cover analytical methods or food composition database management systems in depth. Users of the Study Guide will learn how to compile a food composition database, how to use it and, as analysts, they will learn how their data should be generated and presented so that compilers can make the most use of them.

The Food Composition Study Guide is a tool to assist learners not only to absorb new material but to assess their understanding of the teaching material. It is mainly based on Greenfield and Southgate (2003) and different sources are sometimes indicated when they represent the actual state of the art on these topics. Students are invited to compare them but will not always receive information on which school of thought is preferred.

RELEVANCE

The following table indicates which modules are the most relevant for the different groups of students.

Number of module	Name of module	Relevant for compilers	Relevant for professional users*	Relevant for analysts
1	Basic principles of a food composition programme	●●●●●	●●●●●	●●
2	Use of food composition data	●●●●●	●●●●●	●●
3	Selection and nomenclature of foods in food composition databases	●●●●●	●●●●●	●●
	Components in food composition databases			
4.a	Component selection	●●●●●	●●●●●	●
4.b	Component nomenclature	●●●●●	●●●●●	●●●●●
4.c	Component conventions and units	●●●●●	●●●●●	●●●●●
4.d	Methods of analysing components	●●	●●	●●●●●
5	Sampling	●●●●●	●	●●●●●
6	Quality aspects of analytical data	●●	●●	●●●●●
7	Resources for food composition Publishing food composition data	●●●●●	●●●●●	●●●●●
8	Recipe and other calculations	●●●●●	●●●●●	●
9	Food composition database management systems and data interchange	●●●●●	●●●●●	●
10	Compilation and documentation	●●●●●	●●●●●	●●●●●
10.a	Comparing food composition databases	●●●●●	●●●●●	●
10.b	Case study - translating food intake into nutrient intake	●●●●●	●●●●●	●
11	Quality considerations in data compilation	●●●●●	●●●●●	●●
12	Food biodiversity	●●●●	●●●●●	●●●●●

* A professional user will use food composition data (e.g. to estimate nutrient intake, to produce labels, or to develop diets) and might also compile purpose-driven food composition databases. They are unlikely to sample foods or supervise the analysis of foods.

STRUCTURE

The Food Composition Study Guide is published in two volumes: *Questions and exercises – volume* 1 and *Answers to the questions and exercises – volume 2*. Both volumes consist of 17 modules, grouped under 12 greater subject themes (see the table above). Each module is separated into different sections. The first one states the learning objectives, the material to be studied and an estimation of the time required to complete the module. Often, a list of resources or reference material is indicated along with material for additional reading. The second section contains the questions, the third the exercises. In the volume with the answers, an additional section provides the general feed back.

The questions are structured in a way that allows students to become familiar with the basic terms and concepts, and then gradually increase their knowledge by going through the different topics of the subject. The exercises enable learners to apply their newly-acquired knowledge. The students obtain a certain number of points by answering questions and doing exercises correctly.

The answers section provides responses to the questions and exercises, and contains other information that may be of interest. In many cases, the answers may be found in Greenfield and Southgate (2003). If no other reference is indicated, the page numbers in the answer section correspond to this book (and not to those of the PDF file). At the end of the each answer section, the 'General feedback using self-scoring' gives information on how well students integrate the new knowledge and are able to apply it.

HOW TO PROCEED

It is recommended that students start with 'Required reading', and then answer the questions and complete the exercises. Students will enhance their learning if they try to answer the questions and exercises themselves without looking at the answers. Once this task is completed, they should verify if their answers are correct. In most cases, additional information is provided, either to explain why certain answers are right or wrong or to give more information on the topic. Scoring points are given for each answer, after which the final score can be calculated. With the final score, participants can assign themselves a grade. It is not expected that learners obtain 100% scores in the first run but that they reflect on the issues and learn by doing.

Learners are invited to repeat parts of modules if they did not fully understand the answers to the questions or exercises and, if necessary, read some of the reading material again. Students with an advanced knowledge may wish to answer the questions and exercises without previous reading. They might, however, for some questions have to consult the required reading material to find the answers. Some of the assignments require higher-level thinking in the subject matter. For those students interested in learning more about the topic, a number of documents are suggested for further reading.

After completing the module(s), the students are kindly requested to e-mail (ruth.charrondiere@fao.org or nutrition@fao.org) their score which will help us judge the quality of the module and help us improve it.

HOW TO USE THE STUDY GUIDE TO DEVELOP LEARNING PROGRAMMES ON SPECIFIC TOPICS

Modules of the Study Guide can be reorganized and form the basis of educational programmes in formal or informal training on specific topics or for specific audiences. For example, universities in nutrition and dietetics could be interested in the use of food composition data, while universities in food technology, food chemistry or food safety are mainly interested in the quality aspects of analytical values of different components found in foods. The success of capacity development of individuals is related to the capacity development of institutions and the enabling environment. Firstly, support from higher-level management of one's institution is important as is the inclusion of the new knowledge, skills and attitudes in the mandate of the institution and its procedures. Secondly, factors from the policy-enabling environment influence the success of the capacity development of individuals. For example, issues in policies, funding and political may need to be addressed. This may entail holding seminars and meetings with decision-makers, managers and directors of institutions and politicians. Hence, above and beyond the capacity development of individuals in food composition, it may be necessary to address capacity issues of institutions and the policy-enabling environment.

Example 1. Course on correct use of food composition data

The learning objectives will allow students to understand the principles of food composition database development, management and use and be able to apply them:

- how databases are set up, developed and maintained (including documentation and budget considerations);
- how to involve users, compilers and analysts in food composition programmes;
- where food composition data can be found and how to judge their quality;
- how data should be expressed;
- how data are obtained (including recipe calculations) and compiled, applying quality considerations;
- the importance of high-quality food composition data and their impact on nutrient intakes and adequacy.

For these learning objectives, use of the following modules is recommended, in part or full.

Number of module	Name of module	Estimated time for completion
1	Basic principles of a food composition programme	3-8 h
2	Use of food composition data	3-8 h
3	Selection and nomenclature of foods in food composition databases	3-10 h
4.a	Component selection	3-9 h
4.b	Component nomenclature	3-12 h
4.c	Component conventions and units	3-7 h
7	Resources for food composition Publishing food composition data	3-6 h
8	Recipe and other calculations	4-10 h
10	Compilation and documentation	5-14 h
11	Quality considerations in data compilation	3-9 h

Example 2. Achieving high-quality analytical data for food composition

The learning objectives will allow students to understand the principles of data quality of analytical data generated for food composition purposes and be able to apply them:

- sampling;
- selecting appropriate analytical methods;
- quality aspects of analytical data;
- expression of data (component and foods);
- the importance of high-quality food composition data and their impact on nutrient intakes and adequacy.

For these learning objectives, use of the following modules is recommended, in part or full.

Number of module	Name of module	Estimated time for completion
2	Use of food composition data – exercises only	1 h
3	Selection and nomenclature of foods in food composition databases	3-10 h
4.b	Component nomenclature	3-12 h
4.c	Component conventions and units	3-7 h
4.d	Methods of analysing components	5-16 h
5	Sampling	3-9 h
6	Quality aspects of analytical data	3-9 h
11	Quality considerations in data compilation	3-9 h

Example 3. Importance of food composition data for decision-makers
The learning objectives will allow participants to:
- be able to understand the need for high-quality compositional data for different applications;
- be motivated to fund a national food composition programme and/or the update of the existing food composition table;
- become knowledgeable about the principles of food biodiversity and their impact on food security, dietary intake and adequacy.

For these learning objectives, use of the following modules is recommended, in part or full.

Number of module	Name of module	Estimated time for completion
1	Basic principles of a food composition programme – exercises only	1 h
2	Use of food composition data – exercises only	1 h
3	Selection and nomenclature of foods in food composition databases	3-10 h
4.a	Component selection	3-9 h
4.b	Component nomenclature	3-12 h
11	Quality considerations in data compilation	3-9 h
12	Food biodiversity	3-9 h

Depending on the length permitted for a learning programme, a reduced selection of questions from the modules may be necessary to shorten the time of the seminar if participants have only limited time (e.g. one day).

ADDITIONAL TOOLS AND MATERIAL PUBLISHED TO ACCOMPANY THE FOOD COMPOSITION STUDY GUIDE

The modules are accompanied by PowerPoint presentations available at http://www.fao.org/infoods/presentations_en.stm. Most of them were specifically developed to summarize the important aspects covert in the Study Guide:

- Basic principles for assembling, managing and updating food composition databases by U. Ruth Charrondiere
- Use of food composition data including limitations by U. Ruth Charrondiere
- Food nomenclature by U. Ruth Charrondiere
- Selection of nutrients and other components
- Component nomenclature by U. Ruth Charrondiere
- Component conventions and expressions by U. Ruth Charrondiere
- Proximate system of analysis. PowerPoint Presentation by George Amponsah Annor
- Sampling by U. Ruth Charrondiere
- Sampling of food for analysis by George Amponsah Annor
- Sample collection, handling and preparation by George Amponsah Annor
- Recipe and other calculations by U. Ruth Charrondiere
- Food composition database management systems and interchange by U. Ruth Charrondiere
- Food biodiversity and food composition by U. Ruth Charrondiere

In addition, a simple tool was necessary to apply compilation, calculation and documentation. As such a tool did not exist, the Compilation Tool was developed by FAO/INFOODS, which is freely available at the INFOODS website http://www.fao.org/infoods/SOFTWARE/compilation%20tool%20version1.2.xls together with a user guide. The Compilation Tool has successfully been used in training courses, to compile national food composition databases and databases for biodiversity.

Module 1

BASIC PRINCIPLES OF A FOOD COMPOSITION PROGRAMME

LEARNING OBJECTIVES

By the end of this module the student will be able to:
- understand the objectives of food composition databases;
- run a food composition programme (including budget considerations);
- involve users, compilers and analysts in food composition programmes;
- collaborate internationally;
- know how to obtain food composition data.

REQUIRED READING

- **Charrondière, U.R**. 'Basic principles for assembling, managing and updating food composition databases', available at: http://www.fao.org/infoods/presentations_en.stm

and if possible:
- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use*. FAO, Rome[2]. Introduction and chapters 1–2 (pp. 5–31). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf

RELEVANCE FOR DIFFERENT GROUPS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts ++

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1-4 hours
- Answering the questions: 1-2 hours
- Completing the exercises: 1-2 hours

[2] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to the PDF file.

Answers to the questions

I.Q1 Indicate the correct reasons for compiling and publishing food composition tables and databases. Select True or False. *(4 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 15-19):

Reasons for compiling and publishing food composition tables and databases:	True	False
to analyse nutrient intakes or develop nutrient requirements.	x	
to compare food intakes and relate them to disease outcome.		x
to carry out epidemiological research on the relationship between nutrient intake and disease.	x	
to produce food labels.	x	
to develop new analytical methods.		x
to formulate institutional and therapeutic diets and plan menus.	x	
to promote nutritionally-important plants and animals to improve health or for breeding programmes.	x	
to inform consumers about good food choices.	x	

I.Q2 Before food composition data can be published, a compiler needs to collect the data and manage them systematically. Match the four levels of database management first to their corresponding definition and then to the tasks to be performed by a compiler. *(6.5 points: ½ point for each correct response)*

Levels of database management:
1. Data sources
2. Archival database
3. Reference database
4. User database

Answer (see Greenfield & Southgate, 2003, pp. 10–12):

Definition	Levels
Collection of data that have been scrutinized, standardized, aggregated and completed.	3
Collection in paper or electronic form of published and unpublished literature containing analytical and other compositional data.	1
A subset of the reference database disseminated to the public in different formats: simplified (also called abbreviated or concise), comprehensive (also called unabridged), or special-purpose tables and databases.	4
Collection of records holding the original data of the collected literature in electronic format.	2

For your information:
The archival database should hold all data and metadata in the units in which they were originally published or recorded. Where Excel spreadsheets are used, units and denominators have to be standardized. All values should be documented with metadata, e.g. factors, calculation, sampling plan, numbers of food samples analysed, the analytical methods used and any quality assurance procedures in place. Such records should make it unnecessary to refer back to the original data sources whenever queries arise.

Tasks to be carried out related to different levels of database management	Levels
Update protocols on evaluating, calculating, editing, combining and averaging data	3
Prepare and disseminate different user tables and databases, depending on specific needs	4
Scrutinize (= evaluate) data to obtain good-quality and representative data	2, 3
Assign specific and unique food codes to each food in the database to allow for their retrieval and management within the databases and ensure the traceability of their component values	2, 3*
For users, include concise information on methods, sampling and calculation procedures, nutrient definitions, quality index and literature sources	4
Compile the collected data and metadata into a computerized format and enter all bibliographic references	2
Standardize units and express all nutrients and other components in a uniform manner	3
Collect documents and data files with published and unpublished data	1
Add data (borrowed, calculated, imputed) and document all data sources	3

* Both are possible because most food records are created in the archival database and some in the reference database.

<u>For your information</u>:
The archival and reference database should include all foods with a specific, unique code (never re-use any food code) and all components for which data are available. Through these codes and links between different files, data may be documented in the database with their metadata. The different user tables released should be uniquely referenced and no changes should be published until the next release, unless such changes are notified to users (e.g. indication of version).

I.Q3 List in the correct order the tasks to be undertaken by a newly appointed food composition compiler involved in developing a food composition programme. The plan calls for a database of 400 foods including 20 analysed foods. Start with 1 for the first task and end with 7 for the last. *(3.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 24-29):

Tasks of a food composition compiler	Order of tasks
- Select foods and nutrients	2
- Collect recipes, including ingredients - Compile recipes in the reference database	5
- Develop guidelines for disseminating data to users (e.g. commercial user, research institutes, others) and corresponding costs - Prepare and disseminate user food composition tables and databases	6
- Review, collect and compile existing information into an archival database - Develop (or provide input for) sampling plans and analytical programmes, supervise the analytical programme and evaluate analytical reports	3
- Create a steering committee with stakeholders and users - Obtain training in food composition, e.g. distance learning and/or classroom course - Network with compilers, analysts and users from other countries and with international networks or organizations (e.g. INFOODS Regional Data Centres) - Prepare a budget proposal, and approach potential donors - Obtain information on users' needs	1
- Maintain and update the database continuously	7
- Start compiling foods in the reference database - Obtain refresher training in food composition, e.g. classroom course, study tour and/or distance learning - Incorporate the analytical data into the reference database	4

<u>For your information</u>:
Ideally, foods and nutrients published in user databases should be selected in collaboration with the users or a steering committee.

Experience has shown that training courses are generally more effective when participants already have a certain level of experience and knowledge. Individuals are normally allowed to participate in a postgraduate food composition course only once (especially if sponsored through a fellowship). It is therefore advisable to use the distance-learning tool to acquire sufficient knowledge before starting the food composition programme and/or participating in a classroom training course.

I.Q4 Before starting a national food composition programme, it is highly recommended that steps be taken to ascertain whether another institution or governmental organization is mandated to undertake food composition-related activities. If this is not the case, authorization should be sought from the appropriate government agency (e.g. agriculture, health) to act as coordinator of the national food composition programme. Which of the following statements are reasons for obtaining such authorization? Select True or False. *(2.5 points: ½ point for each correct response)*

Answer:

Reasons for obtaining authorization	True	False
Such authorization may prevent another food composition table being published, with the claim that it is the authoritative (official) table for the country in question.	x	
Such authorization may prevent other food composition tables being published in the same country.		x
Such authorization might result in a budget allocation from the government or other potential donors, both within and outside the country, for the organization to develop, update and maintain a food composition programme.	x	
Such authorization might result in allocated staff time to develop, update and maintain a food composition programme – meaning that food composition work will not be done on a voluntary basis as and when time permits, but as part of the work plan and programmed outputs.	x	
Such authorization charges the organization with developing, updating and maintaining a food composition programme.	x	

I.Q5 Why is it important for food composition data compilers, food analysts and users to interact through national and international networks? Select True or False. *(3 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 13, 24):

Analysts, compilers and users should collaborate, both nationally and internationally, to develop a food composition database that:	True	False
meets the needs of a variety of users because it contains most foods (including foods in the different states in which they are consumed, i.e. 'foods as consumed') and nutrients required by the different users.	x	
is relevant and practical, and presented in a user-friendly format.	x	
is of the highest possible quality, provides updated data and is internationally compatible.	x	
is compiled in accordance with *ad hoc*[3] procedures developed by the compiler, analysts and users.		x
is compiled in accordance with national and international standards for data generation, compilation and management.	x	
may be used without verification in other countries.		x

<u>For your information</u>:
In a given country, the collaboration between compilers and users is cost-effective and normally ensures good-quality food composition data. As a result, the quality of nutrition-related activities (e.g. nutrient intake assessment, nutritional research and nutritional labelling) may be improved. It also ensures that shortcomings, inconsistencies and errors are communicated to the compiler by users, or vice versa.

[3] Only for the specific purpose, case or situation at hand, and not validated.

Countries can learn from each other. Examples of international and regional collaboration are found in 'INFOODS' with its network of regional data centres (available at http://www.fao.org/infoods/index_en.stm), or European projects such as 'EuroFIR' (available at http://www.eurofir.net/).

I.Q6 Indicate the difference between a typical food composition table and a food composition database. Put 1 for 'food composition tables' or 2 for 'food composition databases', or both. *(4 points: ½ point for each correct response)*

Answer (see also Greenfield & Southgate, 2003, pp. 2, 10):

Differences between food composition tables and databases	
Two-dimensional	1
Multidimensional	2
Includes comprehensive documentation	2
Includes little or no documentation	1
Intended for users	1, 2
Printed	1
Computerized	1, 2
Includes archival data, source data, calculations, etc.	2

For your information:
Databases are often managed through database management software, e.g. ORACLE, Access, sql, or simply with Excel spreadsheets. The management of food composition data on paper is obsolete (see module 10 for further information).

I.Q7 Indicate the statements describing a user food composition database which is well-designed and comprehensive. Select True or False. *(7.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 14-15):

Statements describing a well-designed comprehensive user food composition database	True	False
Data should be representative of the foods consumed.	x	
Analytical data should be of sound quality.	x	
It is often better to calculate data than to have missing data.	x	
Coverage of key foods and core nutrients should be as complete as possible.	x	
For all users, it is sufficient to include only raw food.		x
Nutrient values should be limited to those for which analytical data are available.		x
Units of the same nutrients should depend on the concentration in the food, i.e. in g, mg or mcg, depending on the food in question.		x
Food descriptions are optional.		x
Scientific names help identify the food. Food descriptions should be clear.	x	
Data should be consistently and unambiguously expressed.	x	
Metadata should be provided at nutrient value level for advanced users, e.g. researchers, manufacturers.	x	
Data sources should be stated only in the introduction.		x
Tables and databases should be easy to use.	x	
The different user databases should be compatible.	x	
For nutritional epidemiological studies, it is better to have missing data that are treated as zero than to have unreliable data.		x

I.Q8 Plain figures of nutrient values are not meaningful as such; they must be accompanied by the food name and descriptors, the component name and definition, and unit and denominators. In order to facilitate the understanding, use and management of food composition data, the data must also be sufficiently documented with additional metadata, i.e. data about data. Food composition metadata include information on the source and the compositional value: Source description (includes all information needed to identify the origin of the food composition data, e.g. laboratory, literature, etc.), sample descriptions and procedures (which are needed to judge the representativity of the foods); food classification, agricultural production and storage conditions, preservation and cooking methods, food additives or fortificants, value descriptions (include information on source of the value), analytical methods used, uncertainty and specificities of the methods, and statistical description of the analytical data.

Which of the following data are considered either to be food composition data or related metadata? Indicate the correct responses with 'x'. *(5 points: ½ point for each correct response)*

Answer:

Data	Food composition data/ metadata
Component values	x
Component name and definition	x
Food name and description	x
Sampling	x
Source of data	x
Unit and denominator	x
Method information	x
Statistical information of component values	x
Food groups	x
Information about calculation, including recipes	x

I.Q9 Give five reasons why it is necessary to continuously update and maintain a food composition database. *(5 points: 1 point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 29):

Your answer should include any five of the following:
- to ensure that the foods, with their nutrient values in the food composition table, continue to represent the actual food supply and include components of public health significance;
- because food consumption patterns may change, making it necessary to include other foods in the database or to analyse different foods because they become main contributors of nutrients (key foods);
- because new foods may become available on the market;
- because the composition of existing foods change, e.g. fat content of meats, or new formulations of existing brand name foods, or changes in market shares of different brand names;
- because new components are identified for public health significance, e.g. *trans* fatty acids;
- because advances in analytical methodologies may indicate a need to re-analyse foods for particular nutrients;
- because comments on relevance and errors were communicated to the compiler;
- to increase the data quality by replacing borrowed, calculated or imputed values with analytical values.

I.Q10 Many food composition databases and tables are protected by copyright. This measure is intended to protect intellectual property and prevent unwanted use of data. Hence, users are sometimes required to pay a royalty fee. Select the statements that indicate the consequences of copyright protection for compilers and users. *(3 points: ½ point for each correct response)*

Answer: (see Greenfield & Southgate, 2003, p. 29):

Consequences of strict copyright protection for compilers and users	True	False
Compilers have regularly taken legal action against persons using their data without prior permission.		x
Compilers may impose acknowledgement of the data source.	x	
Compilers derive most of the budget for their food composition programme from royalty fees.		x
Users do not have free access to the data and cannot use the data they need, unless they pay the fees.	x	
Some users argue that fees for food composition data should be eliminated or reduced. This is because, in most cases, public funds are used to compile the data and because all food composition databases include data borrowed free-of-charge and sometimes without authorization from scientific and other literature.	x	
Interchange of food composition data is enhanced by copyright.		x

For your information:
Some databases with copyright protection are more restrictive than others. Users prefer food composition tables in the public domain, i.e. databases that are freely accessible and available free-of-charge, for example, that of the United States Department of Agriculture (USDA) (available at http://www.ars.usda.gov/main/site_main.htm?modecode=12354500).

Unless a solution is found to the problem regarding copyright for food composition databases, interchange of compositional data will not be frequent, except for specific purposes and under protective conditions. However, more and more food composition databases are becoming available free-of-charge through the Internet.

Nevertheless, regardless of whether or not databases are copyright protected or are in the public domain, it is important that proper acknowledgement and referencing of sources be systematically made.

I.Q11 List three weak points inherent in food composition data when used to calculate nutrient intake estimations. *(3 points: 1 point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 19-20):

Your answer should include any three of the following:
- The data provide average values of components in foods and, as such, do not accurately reflect the composition of any single food.
- Nutrient variations in foods are not always included owing, for example, to varieties, geography, maturity, processing.
- Data are missing from many food composition tables and databases (e.g. foods, components, nutrient/component values).
- The data may not be comparable over time or across countries.
- Manufactured foods, fortified foods and vitamin and mineral supplements are not always well represented in food composition tables and databases.
- Food composition data may not represent foods consumed in the country when values are imputed, calculated or borrowed, or if they are of low analytical quality or based on few samples.
- Missing documentation makes it impossible to assess the quality of the data.

SAMPLE ANSWERS TO THE EXERCISES

I.E1 A compiler has obtained US$200,000 from the government to develop, within a period of two years, the first national food composition programme. The food composition database should contain at least 400 foods. Twenty foods representing the main contributors to nutrient intake estimations should be analysed. Draw up a budget by choosing from the following elements. No amount may be changed. *(15 points)*

Elements to draw up a budget	US$
Salary per compiler per year (producing data for 200 calculated/ borrowed foods **OR** for 20 analysed foods)	20,000
Cost per food analysis if outsourced and analysed in duplicate: - of main nutrients (macronutrients, minerals, selected vitamins) - of macronutrients (water, ash, AOAC dietary fibre, protein, fat, ash) - of fatty acid profile - of amino acid profile - of minerals (ICP method for 22 elements) - per vitamin	 1,000 300 150 100 200 100
Sampling cost for all food samples for one food (including collection, purchase and transportation of several representative samples of each food collected in accordance with the sampling plan)	500
Running costs of a laboratory per year (rental, salaries, chemicals, etc.)	40,000
Purchase of essential laboratory equipment	100,000
Purchase of computer and basic software	3,000
Cost of food composition database management system	10,000
Cost of purchasing other food composition databases and tables	1,000
Expert consultant costs per week	1,000
Cost of one meeting with steering committee	500
Publication costs (printing of 1,000 copies, website dissemination)	3,000
Cost of meeting to launch user database	1,000
Cost of participating in the International Food Data Conference	2,000
Cost of participating in a regional INFOODS meeting	1,000
Cost per participant in food composition course	5,000
Use of distance learning tool *Food Composition Study Guide* to increase knowledge of food composition	0
Annual running costs (telephone, photocopying, electricity, office administration, etc.)	5,000
Possible income	
Price per printed food composition table	20

Answer – example:

Individual correct answers may vary. You obtain points if you provide for: (●) an adequate salary for the compiler; (●●●) adequate budget for analysis – analyse as first priority key foods for selected nutrients (see module 3); (●) costs of sampling based on the number of samples to be analysed; (●) purchase of computer, (●) software and database management system; (●) costs of other food composition sources; (●) publishing, (●) training and (●) annual running costs. Other optional, albeit recommended, costs are for (●) participation in conferences, (●) INFOODS meetings or a (●) launching meeting. If you have attempted to create a laboratory, you will have concluded that the funds available are insufficient. You get a bonus of 2 points if you remain within the US$ 200,000.

Budget - Example	US$
Salary per compiler per year. Chosen to calculate/estimate 600 foods and to analyse 40 foods: 5 x 20,000	100,000
Cost per food analysis if outsourced.	
- **Analysis of main nutrients (macronutrients, minerals, selected vitamins).** Chosen for the 20 staple foods: 20 x 1,000	20,000
- **Analysis of macronutrients (water, ash, AOAC dietary fibre, protein, fat, ash).** Chosen for the remaining 20 foods because macronutrients are important: 20 x 300	6,000
- **Analysis of fatty acid profile**. Chosen for the five key foods for fat: 5 x 150	750
- **Analysis of amino acid profile.** Not chosen for the first edition.	
- **Analysis of minerals (ICP method for 22 elements).** Chosen for the remaining 20 foods because minerals are important and the analysis is inexpensive: 20 x 200	4,000
- **Analysis of vitamins – per vitamin**. Vitamin C chosen for key contributors – mainly vegetables and fruits (10 foods); vitamin B_{12}, vitamin D and retinol for key contributors – mainly animal products (seven foods x 3 vitamins); α- and β-carotene for key contributors – mainly in fruits and vegetables (10 foods); vitamin E for key contributors – mainly vegetable oils (three foods); folate for key contributors – mainly fruits and vegetables, fortified cereals and some cheese (10 foods); thiamin for key contributors – mainly cereals, vegetables, pork (seven foods); riboflavin for key contributors – mainly dairy products, egg, offals (seven foods); and niacin for key contributors – protein rich foods, e.g. meat, fish, groundnut, cereals (four foods). Total 81 x 100	8,100
Sampling cost per food. 40 foods: 40 x 500	20,000
Running costs for a laboratory for one year (rental, salaries, chemicals, etc.). Not chosen because of outsourcing	
Purchase of essential laboratory equipment. Not chosen because of outsourcing	
Purchase of computer and basic software. Two computers: 2 x 3,000	6,000
Cost of food composition database management system. Chosen because it is useful for managing and documenting data and for producing different user databases: 1 x 10,000	10,000
Cost of purchasing other food composition databases and tables. Chosen because it is useful for comparing one's own analytical results with composition of similar foods in other countries and as a source for borrowing data: 1 x 1,000	1,000
Expert consultant costs per week. One-week consultancy at start to check that procedures are correct for the generation and compilation of data, and one week before printing to check the final data: 2 x 1000	2,000
Cost of one meeting with steering committee. One meeting at the beginning of the project to seek committee support and ensure that components and foods of interest to users are included. Another meeting towards the end of the project to present data and obtain feedback: 2 x 500	1,000
Publication cost (printing of 1,000 copies, website dissemination). Chosen because the user database needs to be distributed to users, e.g. consumers, food industry, institutions, private practitioners. The website may be used for data dissemination. 1 x 3,000	3,000
Cost of meeting to launch user database. Chosen because it may be important to present work to potential users and donors and perhaps as part of a dissemination strategy. One alternative would be to take advantage of another meeting/conference to launch the database – in that case, it may cost much less: 1 x 1,000	1,000
Cost of participating in the International Food Data Conference. Chosen because it provides an opportunity to learn from, and network with, other compilers, analysts, scientists, and to present one's own work at international level. Two participants: 2 x 2,000	4,000
Cost of participating in a regional INFOODS meeting. Chosen because it provides an opportunity to learn from, and network with, others at the regional level, to collaborate on all aspects of food composition (analyses, calculation systems, etc.) and to report on achieved progress. Two participants: 2 x 1,000	2,000
Use distance learning tool *Food Composition Study* Guide to increase knowledge of food composition. Chosen for initial training and refresher training.	0
Cost per participant in a food composition course. Chosen because the course imparts basic knowledge of food composition while providing an opportunity to learn from and network with others. One participant: 1 x 5,000	5,000
Annual running costs (telephone, photocopying, electricity, office administration, etc). Chosen because in many cases these costs are unavoidable: 1 x 5,000 =	5,000
Possible income	
Price per printed food composition table. Not chosen because this is not cost-effective (too time-consuming and providing little income)	-
Total: US$198,850	

<u>For your information</u>:
The amount of US$200,000 is not a large enough sum for developing a food composition programme and publishing a database. It is therefore unrealistic to attempt to install a laboratory with this level of funding. It will be necessary to purchase instruments, train analysts, validate methods and work out a good routine for running the analyses, and implement a data quality assurance programme (see module 6). As it also takes a considerable amount of time to obtain good analytical results, it is more cost-effective to out-

source nutrient analysis at the beginning of a food composition programme. Once the food composition programme has published a number of editions, consideration may be given to establishing and maintaining a laboratory for nutrient analyses, if sufficient funds are allocated on a long-term basis.

The foods and nutrients contributing most to the nutrient intake of the population (see the key food approach in module 3) should be (re-)analysed. The time and resources needed to establish a sampling plan and to carry out food sampling are often underestimated (see module 5).

The potential income from selling food composition databases is very low compared with the cost of generating them. Selling food composition tables and databases cannot be considered as a good source of income and therefore it may be more cost-effective to provide food composition tables to non-commercial users in electronic form free-of-charge.

It might be useful to repeat this exercise after completion of all other modules.

I.E2 The compiler realizes that the US$200,000 provided by the government is not enough to complete the food composition database. List two options for the compiler to obtain more funding. *(2 points: 1 point for each correct response)*

Answer:

Your answer should include any two of the following:
- submit an additional budget proposal to the government, explaining how the additional funds would be used and describing what the advantages would be to the government and other stakeholders;
- collaborate with the private sector;
- submit a project proposal to potential funding agencies at the national, regional or international levels;
- reduce analytical work and compile more foods from other sources;
- reduce the coverage of foods and/or nutrients.

I.E3 One member of the food composition programme steering committee is the most famous nutrition researcher in the country. She has recently undertaken a food consumption survey based on 24-hour-recalls, and brings a list with 1,000 foods to be included in the food composition table, including numerous recipes, prepared foods and brand name foods. Originally, the compiler thought of including only raw foods in the database and no brand name or prepared foods. List two arguments by the researcher for including raw, cooked and brand name foods and two arguments by the compiler for including only raw foods. *(4 points: 1 point for each correct response)*

Answer:

Your answer should include any two of the following arguments for including <u>only raw foods</u> in the food composition table and database:
- Data on raw foods are more reproducible, less variable and therefore more reliable and stable.
- There is no need for other data if mainly household budget surveys, which are based on raw foods, are carried out in the country.
- Because of the wide range of cooking methods and variations in ingredients/quantities in recipes, there is more variability in the nutrient values of cooked foods and recipes. Therefore, they are less representative compared with the nutrient values of raw foods. For these reasons, they are not included in food composition tables or databases.
- Time and costs are saved if only raw foods are included.
- There is a high coverage of raw foods as other forms of food do not need to be considered.

Your answer might include any two of the following arguments for including raw, cooked and brand name foods in the food composition table and database:

- Because the compiler is more knowledgeable about the generation and compilation of food composition data, the quality of the data will be better if the compiler provides data sets with nutrient values that include cooked and brand name foods.
- It is easier for users to match the food "as consumed" with the corresponding food in the food composition database, especially for food consumption surveys that report foods "as consumed". The food match would then be less likely to be erroneous.
- The nutrient intake estimations are of better quality and are likely to contain fewer errors compared with using a food composition table with only raw foods. This is because the user will not need to establish an *ad hoc* recipe calculation system.
- Many users are not aware that the nutrient values of raw foods are different from those of foods "as consumed". Applying the nutrient values of raw foods to processed foods leads to errors in nutrient intake estimations and thus in all research results and policy decisions based on them.
- It is important to capture brand name foods in the food composition database because they are often unique in composition and allow for more accurate nutrient intake estimations, especially if part of the food supply is fortified.

Answers might not be exhaustive.

GENERAL FEEDBACK USING SELF-SCORING

55 – 68.5 points: You have fully understood and integrated the principles for food composition data and for developing a food composition data programme. Congratulations. You are well prepared to proceed to the next module and to apply the new knowledge.

40 – 54 points: You have understood and integrated most of the principles for preparing food composition data and for developing a food composition data programme. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so in order to effectively apply the new knowledge.

20 – 39 points: You have understood and integrated a fair part of the principles for preparing food composition data and for developing a food composition data programme. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

0 – 19 points: It seems you have significant gaps in your understanding of the principles for preparing food composition data and for developing a food composition data programme. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

Module 2

USE OF FOOD COMPOSITION DATA

LEARNING OBJECTIVES

By the end of this module the student will be able to:

- understand who uses food composition data and for what purpose;
- understand the importance of high-quality food composition data:
- understand the role of food composition data in nutrient intake estimations and apply them correctly;
- understand users' requirements;
- consider limitations in food composition data in their use;
- recognize errors in the application of compositional data and know how to minimize them.

REQUIRED READING

- **Charrondière, U.R**. 'Use of food composition data including limitations', available at: http://www.fao.org/infoods/presentations_en.stm

and if possible:

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use.* FAO. Rome[4]. Chapters 1 (pp. 5–22), 2 (p. 29), 10 (pp. 178-182, 185-186) and 11 (pp. 187-198). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf

RELEVANCE FOR DIFFERENT GROUPS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts ++

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1-4 hours
- Answering the questions: 1-2 hours
- Completing the exercises: 1-2 hours

SUGGESTED ADDITIONAL READING

- **Greenfield, H.** 1990. Uses and abuses of food composition data**.** Supplement to *Food Australia 42 (8),* editor. Available at: http://www.fao.org/docrep/008/af281e/af281e00.htm
- **Rand, W.M., Windham, C.T., Wyse, B. W. & Young, V.R.** 1987. *Food Composition Data: a User's Perspective.* United Nations University, Tokyo. Available at http://www.unu.edu/unupress/unupbooks/80633e/80633E00.htm
- **Burlingame, B**. 2004. Fostering quality data in food composition databases: visions for the future. *Journal of Food Composition and Analysis* Volume 17, Issues 3-4, pp. 251-258. Available at:: http://www.sciencedirect.com/science?_ob=publicationurl&_tockey=%23toc%236879%232004%23999829996%23503542%23fla%23&_cdi=6879&_pubtype=j&view=c&_auth=y&_acct=c000055286&_version=1&_urlversion=0&_userid=1916222&md5=6f1b1023d9c078822b8fb6357f898f22

[4] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to the PDF file.

Answers to the questions

II.Q1 Match the users of food composition tables and databases to their main application of food composition data. Each user should be matched to one main application. *(6 points: ½ point for each correct response)*

Users:

1. Nutritionists/dietitians
2. Food scientists/food manufacturers
3. Food chemists
4. Decision-makers at government level
5. Professionals working in agriculture
6. Economists
7. Consumers
8. Epidemiologists
9. Teachers
10. Professionals working in biodiversity
11. Professionals working in food safety and risk assessment
12. Professionals working in food aid

Answer (see Greenfield & Southgate, 2003, pp. 12, 20; Burlingame, 2004):

	Main application of food composition data
7	To decide on a diet for losing weight
2	To estimate nutrient changes in new food processing methods and produce food labels on nutrient composition
1	To calculate nutrient intakes, advise patients on specific diets, e.g. in connection with anaemia and/or diabetes, and to draw up therapeutic diets
4	To assess the impact of food fortification and decide on the levels thereof
6	To calculate the impact of inadequate nutrient intake on a country's economic development
12	To assess the adequacy of food aid rations
5	To decide which variety, cultivar or breed is nutritionally superior and would be suitable for agricultural research
9	To teach pupils about nutrition
10	To identify the use and value of different varieties, cultivars or breeds and determine their impact on health
3	To compare their own analytical values with existing composition data to estimate the validity of results
11	To calculate exposure to contaminants that dissolve in fat, e g transmission of packing material to food, depending on its fat content; or to determine safe upper limits for nutrients
8	To relate folate intake to cancer risk

For your information:
The article by Burlingame (2004) lists additional users, for example, food biotechnology, pharmacology, or plant breeding. Further information on terms such as breed, cultivar or variety is given in module 12 on food biodiversity.

II.Q2 How is it possible to satisfy the requirements of different users when compiling user food composition tables and databases? Select the correct statement. *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 12):

	Satisfaction of different users when compiling user food composition tables and databases
x	Several types of user databases and tables should be published, e.g. abbreviated (or simplified), comprehensive or special-purpose tables and databases in printed or electronic form.
	One user food composition database fits the needs of all.

For your information:
There should be several types of user databases, e.g. abbreviated, simplified, comprehensive or special-purpose tables and databases, because different users have different needs, ranging from simple to comprehensive coverage of foods, nutrients and documentation.

Optional question for persons with advanced knowledge or who have participated in a food composition course
II.Q3 The Codex Alimentarius Commission is currently discussing the possibility of making nutrient content information mandatory on food labels. What impact is this likely to have on food composition work? Select True or False. *(3 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 18-19):

True	False	Likely impact of mandatory nutrient-content labelling on food composition work
x		Governments and manufacturers may become more interested in generating analytical compositional data and in supporting a food composition programme.
	x	If food composition data, even of low quality, are available in a country, there are no grounds for requesting additional support from the government (or manufacturers).
x		Governments may have to decide if and which food composition databases may be used for nutritional labelling.
	x	Food composition tables from other countries provide accurate content information on national foods for the national and other markets.
x		Manufacturers (and governments) might become more supportive of high-quality food composition data if food products were detained or confiscated at the borders of other countries owing to non-compliance with other countries' labelling legislation.
	x	Manufacturers will generate more compositional data on specific ingredients and give them with all metadata to the food composition programme for publication.

II.Q4 Provide the formula to calculate the nutrient intake estimations of an individual. *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 15):

$$I = \sum(W1C1 + W2C2 + W3C3 + \ldots\ldots WnCn)$$

where: I = intake of the nutrient, W1 = weight consumed of food 1, C1 = content of the nutrient in food 1, expressed per g or mL, etc.

For your information:
The nutrient intake estimations are calculated by multiplying the weight of each reported food by the content of nutrients in the foods. This is calculated for every food consumed. The sum represents the estimated nutrient intake, for example, of one day.

It is most important to match the correct food from the food composition table to the corresponding food consumed. It is necessary to check that the units and denominator of the foods from the survey are the same as the corresponding food from the food composition database, and, if needed, to convert the units (e.g. from mL to g). Special attention needs to be given to liquids. Care should be also taken to ensure that nutrient values in food composition databases and tables are normally expressed per 100 g edible portion. Therefore, the weight of reported foods including inedible parts have transformed into the weight of the edible portion of the food. More information on units and expressions may be found in module 4.c.

II.Q5 The quality of the nutrient intake estimation depends on that of the food intake estimation and the food composition data. From the following list, indicate those reasons which introduce errors when estimating food intakes. Select True or False. *(3.5 points: ½ point for each correct response)*

Answer (see also Greenfield & Southgate, 2003, p. 195):

True	False	Reasons for errors in food intake (or food supply) estimations
x		Due to inherent uncertainties of food consumption data they cannot represent the true (actual or long-term) food intake of individuals, households, groups or nations. They are only estimates.
x		Subjects of food consumption surveys may introduce errors due to faulty or incomplete recall of foods consumed.
x		Errors may be introduced due to survey tools, methodology and study design.
x		Subjects of food consumption surveys may introduce errors by under- or over-reporting specific foods.
x		Errors may be introduced due to the absence of density data to convert volume to mass measures.
	x	Statistical treatment of data makes it possible to eliminate all bias.
x		Errors may be introduced due to improper matching of reported foods with foods in the food composition database.

II.Q6 Indicate whether food categories are well covered in most food composition tables/databases. Select True or False. *(3.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 20, 191):

Well-covered food categories	True	False
Brand name foods/commercial products		x
Raw foods	x	
Cooked foods		x
Ready-to-eat foods		x
Recipes		x
Different varieties/cultivars/breeds of the same food		x
Mineral and vitamin supplements		x

For your information:
Users require raw foods in food composition tables and databases, as well as 'foods as consumed' (i.e. in the form that they are eaten such as recipes or cooked, ready-to-eat and brand name foods). However, 'foods as consumed' are rarely included in food composition databases and tables. Users increasingly seek compositional data on different cultivars and varieties of e.g. fruits and vegetables and for mineral and vitamin supplements. Compilers should take greater account of these needs.

A directory of food composition tables and databases may be found on the INFOODS web site, available at: http://www.fao.org/infoods/directory_en.stm, and on the LanguaL web site available at http://www.langual.org/langual_linkcategory.asp?CategoryID=4&Category=Food+Composition.

II.Q7 When food composition tables and databases have a poor coverage of certain food categories (as mentioned in II.Q6), what impact can this have on the accuracy of nutrient intake estimations? Select the correct response. *(1 point)*

Answer (see Greenfield & Southgate, 2003, pp. 20,191):

Poor coverage of these food categories in food composition tables and databases leads to nutrient intake estimations that:	
are representative of the actual nutrient intake because most foods are consumed raw.	
underestimate the mineral and vitamin intake in given countries, especially if fortified foods and nutrient supplements are widely consumed.	x
underestimate nutrient intake estimations for populations with a high consumption of rice in the event the nutrient values of raw rice are attributed to cooked rice.	
result in high-quality nutrient intake estimations because the nutrient values of raw foods are similar to those of prepared foods.	
result in high-quality nutrient intake estimations because over-estimations are balanced by underestimations, i.e. random errors balance each other out.	

II.Q8 What has a greater impact on nutrient intake estimations: an error in the nutrient composition of foods consumed in large or small amounts? Select the correct response(s). *(2 points: ½ point for each correct response)*

a) In general, errors in nutrient intake estimations are greater where larger amounts of food are consumed;
b) In general, errors in nutrient intake estimations are great even if the foods are consumed in small amounts;
c) In general, errors in nutrient intake estimations are great if the foods are consumed in small amounts but have a high concentration of nutrients;
d) In general, errors in nutrient intake estimations are the same for foods consumed in large or small amounts.

Answer: a and c

II.Q9 What has a greater impact on the nutrient intake estimation of a single nutrient: a systematic 30% underestimation of the nutrient value(s) in all foods or a 30% underestimation of the food intake? Select True or False. *(2 points: ½ point for each correct response)*

Answer:

Impact on nutrient intake estimations	True	False
A systematic 30% underestimation of the values of a specific nutrient has a greater impact on its nutrient intake estimation compared with a 30% underestimation of food intake.		x
A 30% underestimation of food intake has a greater impact on the nutrient intake estimation compared with a systematic 30% underestimation of the nutrient values of a specific nutrient.		x
The impact on the nutrient intake estimation is the same whether the nutrient values are systematically underestimated in all foods or the food intake is underestimated by the same percentage.	x	
The nutrient intake is underestimated by 30% in both cases.	x	

Explanation:
There is no difference in the nutrient intake estimation when the food intake or all nutrient values are systematically underestimated because the nutrient intake calculation is a multiplication. Therefore, if either of the two components of the multiplication (i.e. food intake or nutrient content) is underestimated by 30%, the nutrient intake estimation is off by the same percentage.

Example:

True intake and true nutrient value	100 g x 10 g fat/100 g = 10 g fat
True intake and 30% underestimation of fat	100 g x 7 g fat/100 g = 7 g fat
30% underestimation of true food intake and correct nutrient value	70 g x 10 g fat/100 g = 7 g fat

II.Q10 List four reasons for changes or differences in nutrient intake estimations over time. *(4 points: 1 point for each correct response)*

Answer (see also Greenfield & Southgate, 2003, p. 193-195):

Your answer should include any four of the following:
- Real differences in food composition over time;
- Artefactual differences in nutrient values, e.g. due to an analytical method generating non-comparable results, new analytical data, different nutrient definition or expression;
- Updating of outdated or incorrect values;
- Differences in coverage of foods and nutrients between different food composition data sources;
- Different calculation methods;
- If compositional data from other countries are used, they may differ in nutrient contents for the following reasons: levels of fortificants in their fortified foods, varieties of fruits and vegetables, soils with higher or lower element contents, environmental or production conditions, market shares of products in aggregated food items, etc.
- The population eats different foods over time.

For your information:
Using different food composition tables and databases, the nutrient intake estimations may be either over- or underestimated by as much as 60%.

II.Q11 Match the errors in nutrient intake estimations to the corresponding category: limitations in survey tool or design; food matching; and calculation. Select the most important category for each error. *(7.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 188-197):

Errors in nutrient intake estimations due to:	Limitations in survey tool or design	Food and component matching	Calculation
failing to record either the fat or oil used for cooking or to record the cooking method (important for calculating correct fat and fatty acid intake).	x		
selecting incorrect foods in the food composition table due to insufficient details in the food description in the survey and/or the food composition table or database (e.g. missing cooking or processing method) or due to insufficient knowledge about foods.		x	
calculating fatty acid intakes from fatty acids per 100 g of total fatty acids instead of per 100 g of food.			x
selecting nutrient values of a food with inedible portion (total food) for the same food without inedible portion, and vice versa.		x	
applying nutrient values of a non-fortified food to a reported fortified food.		x	
failing to recognize differences in nutrient values owing to different nutrient expressions, e.g. available carbohydrates vs. total carbohydrates.		x	

Errors in nutrient intake estimations due to:	Limitations in survey tool or design	Food and component matching	Calculation
using incorrect conversion factors, e.g. vitamin A or folate.			x
selecting incorrect foods in the food composition table due to problems of language when data are taken from other countries. Even in one language, identical foods may have different names and different foods may have the same name. Examples here are corn and maize, or in different countries the same names of meat cuts might come from different parts of the animal.		x	
failing to include pro-vitamin A carotenoids when estimating vitamin A intake.		x	
applying wrong conversions (volume to weight, portion description to weight). This occurs rather frequently.			x
selecting a raw food instead of a cooked one (different nutrient values!).		x	
imputing values of nutritionally different foods when estimating nutrient values of missing foods or values.		x	
using inappropriate or outdated recipes and recipe calculation systems, or not recording water as an ingredient.			x
using uncertain food consumption data, e.g. owing to study tool or study design.	x		
failing to adjust for water, vitamin and mineral losses (or gains) when calculating nutrient intake from a recipe.			x

II.Q12 For some nutrients, the nutrient values depend on the nutrient definition, expression and analytical methods used. Examples are energy, fibre, carbohydrates, fat, protein, vitamins A, C, D and E, folate, niacin and carotenes. The nutrient values may not be comparable and if different food composition tables and databases are used, there may be systematic differences in nutrient intake estimations among countries and over time. What should the user do to minimize errors in when estimating nutrient intakes and/or when using the nutrient intake estimations of others? Select True or False. *(2.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 178-182):

How users can minimize errors	True	False
Professional users of food composition tables and databases should always check the nutrient definition used in the table or database, e.g. in the introduction to the table or in the documentation of the database.	x	
Professional users of food composition tables and databases should know the nutrients for which values may differ significantly due to definition, expression, analytical method and unit.	x	
If estimated nutrient intakes from different studies are to be compared, the nutrient definition, analytical methods and expression should be checked for all nutrients. This will allow the user to understand which nutrient intake estimations are comparable.	x	
Users of food composition tables and databases do not need to search for the nutrient expression (e g. total vs. available carbohydrates vs. available carbohydrates in monosaccharide equivalents) in the introduction to the table or database.		x
If estimated nutrient intakes from different studies are to be compared, there is no need to be concerned about nutrient definition and expression. The impact on nutrient intake estimations and on correlations (to health outcome, for example) is, at best, only marginal.		x

For your information:
Users should be aware of nutrients that call for special attention when comparing nutrient intake estimations or compiling a food composition table or database. The following are examples where nutrient values differ significantly due to definition, expression, analytical method and unit:

- Fibre, e.g.: AOAC/Prosky fibre vs. Englyst/NSP[5] fibre vs. crude fibre;
- Carbohydrates: total carbohydrates vs. available carbohydrates by difference vs. available carbohydrates vs. available carbohydrates in monosaccharide equivalents;
- Folate: microbiological vs. HPLC determination;
- Niacin: niacin preformed vs. niacin equivalent;
- Vitamin A: retinol vs. retinol equivalent (RE) vs. retinol activity equivalent (RAE);
- Vitamin A: in mcg or IU;
- Vitamin E: α-tocopherol vs. α-tocopherol equivalent;
- Vitamin K: bioassay vs. HPLC.

More details are given in modules 4.b and 4.c.

II.Q13 What can a compiler do to minimize the above-mentioned errors? Select the correct response(s). *(2.5 points: ½ point for each correct response)*

a) Train all users
b) Improve food description and coverage, including foods as consumed, recipes and brand name foods
c) Improve nutrient description and coverage
d) Improve documentation
e) Nothing, as the errors are made by users.

Answer (see Greenfield & Southgate, 2003, pp. 188-197): b, c and d

For your information:
Persons responsible for food consumption surveys might also improve their survey tools, methodology, or survey design and enhance the food coverage and description in their study tool.

II.Q14 Some users who wish to achieve good-quality nutrient intake estimations are faced with either a food composition database containing missing data or without an existing national composition table. Missing foods means that the foods do not exist in the database. A missing nutrient means that the nutrient does not exist in the database, and a missing value means that one nutrient value is not reported for a food. In such cases, users are obliged to estimate, calculate or borrow the missing compositional data themselves. In the table below, match the missing data to the corresponding example and remedy. *(3 points: ½ point for each correct response)*

Examples of missing food composition data:
1. No dietary fibre in the food composition table;
2. Missing vitamin C value for raw tomato;
3. Fried beef fillet is missing in database, whereas raw beef fillet may be included.

Remedies to estimate missing data:
4. Use compositional data from other sources, including other countries;
5. Calculate data using recipes or other algorithms;
6. Estimate data on the basis of own knowledge.

[5] NSP = non-starch polysaccharides

Answer:

Missing data	Missing data example	Remedy
Missing nutrient value	2	6
Missing food	3	5
Missing component	1	4

For your information:
Many users may have difficulties with regard to evaluating differences in nutrient definitions; differences in foods from other sources and countries; or differences in nutrient values and/or nutrient intake estimations due to different food descriptions, recipe calculation systems and missing values. Using the national food composition table of another country presents a major challenge to users, as none of the data have been previously evaluated by a national compiler for their applicability to their own country. In addition, language problems and unfamiliarity with the foods of these countries may make it more difficult to understand the data.

Higher-quality nutrient intake estimations may be achieved when in addition to raw foods the compiler, who has a good knowledge of food composition data, includes the major foods and recipes consumed in the published food composition table and database, as well as the nutrients of greatest national interest, e.g. those with public health implications.

II.Q15 Software packages with compositional data are often delivered to users without information on data source, extent of missing values, nutrient definitions, etc. Indicate the consequences for users when calculating nutrient intake estimations or nutrient contents on labels with such software packages. Select True or False. *(2 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 194-195):

True	False	Consequences for users of such software packages
	x	Nutrient values on labels are exact.
x		The quality of the nutrient intake estimations cannot be assessed.
x		The nutrient intake estimations cannot be clearly defined (niacin vs. niacin equivalent or available vs. total carbohydrates).
x		The nutrient intake estimations may be underestimated owing to missing nutrient values.

II.Q16 In most cases, food composition data are not comparable across countries and over time. Select True or False. *(2 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 188-195):

True	False	Reasons for non-comparability of nutrient values across countries and over time
	x	Universal use of analytical methods
x		Artificial differences due to nutrient definition, method used, source of data and data expression
	x	Unique worldwide source of data (INFOODS)
	x	Foods with same food name have the same food composition across countries and over time

For your information:
In recent years, greater efforts have been made to harmonize or standardize food composition data across countries.

II.Q17 Horwitz found a correlation between the concentration of a component and the variability of analytical results (see Greenfield & Southgate, 2003, p. 87 of Greenfield and Southgate, 2003), i.e. the lower the concentration the lower the accuracy or precision of a method or the higher the coefficient of variation. What impact does the concentration of a component have on the accuracy of nutrient intake estimations and their correlations to health outcomes? Select the one correct statement.
(1 point)

Note: See Horwitz trumpet at http://www.rsc.org/images/brief17_tcm18-25961.pdf

Answer:

	Statement concerning the impact of the concentrations of components on the accuracy of nutrient intake estimations and their correlations to health outcomes
x	According to Horwitz, at 1 ppm (100 mcg/100g food) the accepted analytical variability is +/-20% and at 100 ppm (10 mg/100g food) it is +/-10%. Some nutrients are present in foods at these concentrations such as iodine, selenium, folate, panthotenate, biotin, vitamin B12, and in many foods also retinol and carotenes. If the difference in nutrient intake estimations for these nutrients is below 10%, even if found significant at 0.05, it would be advisable not interpret the correlation as being of a significant difference because it is within the analytical variability.
	Analytical precision and accuracy have no impact on the accuracy of nutrient intake estimations or their correlations to health outcomes. The accuracy of the nutrient intake estimation depends only on the food consumption survey design, the subjects and the quality of the analytical method or compilation.
	The analytical methods for macronutrients have a lower analytical precision and accuracy compared with trace elements and other nutrients present in microgram amounts. They therefore generate nutrient intake estimations with less precision.

For your information:
Analytical precision and accuracy are also dependent on instrumentation and methods used, which have their own ideal range for concentrations. In general, the higher the concentration, the greater the analytical precision and accuracy. Therefore the macronutrient intake estimations are more precise compared to those of trace elements.

SAMPLE ANSWERS TO THE EXERCISES

II.E1 Calculate the total nutrient intake for the foods in the table below. The nutrient values correspond to the amount of foods consumed in one meal, as stated in the column "consumption". *(4 points: ½ point for each correct response)*

Answer:

Food item	Consumption (g)	Energy (kJ)	Protein (g)	Dietary Fibre (g)	Fat (g)	Ca (mg)	Fe (mg)	Vitamin C (mg)
Rice, cooked	200	1086	5.4	0.8	0.6	20	2.4	0
Carrot, boiled	50	73	0.35	1.5	0.1	15	0.15	-
Meat, cooked	100	1274	25.9	10	21.5	10	2.6	0
Milk	100	250	3.2	0	3.2	204	0.03	0
Total intake	450	2683	34.85	12.3	25.4	249	5.18	0

II.E2 Users did not previously find a vitamin C value for boiled carrot. Now they find a value for raw carrot in a food composition table (5.9 mg/100 g) and decide to borrow and apply it. Use the missing value for vitamin C for raw carrot. Recalculate the total nutrient intake and discuss the result in relation to the recommended daily intake of 60 mg/d. *(2 points - ½ point for each correct calculation and 1 point for the explanation)*

Answer:

Food item	Consumption (g)	Energy (kJ)	Protein (g)	Dietary Fibre (g)	Fat (g)	Ca (mg)	Fe (mg)	Vitamin C (mg)
Rice, cooked	200	1086	5.4	0.8	0.6	20	2.4	0
Carrot, boiled	50	73	0.35	1.5	0.1	15	0.15	2.95
Meat, cooked	100	1274	25.9	10	21.5	10	2.6	0
Milk	100	250	3.2	0	3.2	204	0.03	0
Total intake	450	2683	34.85	12.3	25.4	249	5.18	2.95

The estimate of vitamin C intake increased from 0 mg to 2.95 mg, corresponding to about 5% of the vitamin C requirement (60 mg/d), which has a significant impact on the estimate of the nutrient intake for this meal. Before imputing the value of the raw carrot, the user should, however, correct the value for the change in weight and loss of vitamin during cooking. The vitamin C content of raw carrot is higher than that of cooked carrot.

II.E3 In another food composition table, a user finds that the vitamin C content of boiled carrot is 3.6 mg/100 g. Replace the vitamin C value of raw carrot with the newly-found value for boiled carrot. Recalculate the total nutrient intake and discuss the result in relation to using the vitamin C value of a raw food for a cooked food. *(2 points - ½ point for each correct calculation and 1 point for the explanation)*

Answer:

Food item	Consumption (g)	Energy (kJ)	Protein (g)	Dietary Fibre (g)	Fat (g)	Ca (mg)	Fe (mg)	Vitamin C (mg)
Rice, cooked	200	1086	5.4	0.8	0.6	20	2.4	0
Carrot, boiled	50	73	0.35	1.5	0.1	15	0.15	1.8
Meat, cooked	100	1274	25.9	10	21.5	10	2.6	0
Milk	100	250	3.2	0	3.2	204	0.03	0
Total intake	450	2683	34.85	12.3	25.4	249	5.18	1.8

Compared with the missing value treated as zero, the estimate of the vitamin C intake increases from 0 mg to 1.8 mg – which is less than if the vitamin C value of raw carrot was used (the estimate of the vitamin C intake decreased from 2.95 mg to 1.86 mg in the meal). As nutrient values of raw and cooked foods may be very different, they have a significant impact on nutrient intake estimations. In this case, the nutrient intake estimation is lower for vitamin C using cooked instead of raw carrot because of the loss of vitamin C in cooking.

II.E4 A user made an error when copying the fibre value of meat, which should have been 0. Recalculate the total nutrient intake using the results of II.E3 and discuss the result in relation to the errors in copying values. *(1.5 points - ½ point for the correct calculation and 1 point for the explanation)*

Answer:

Food item	Consumption (g)	Energy (kJ)	Protein (g)	Dietary Fibre (g)	Fat (g)	Ca (mg)	Fe (mg)	Vitamin C (mg)
Rice, cooked	200	1086	5.4	0.8	0.6	20	2.4	0
Carrot, boiled	50	73	0.35	1.5	0.1	15	0.15	1.8
Meat, cooked	100	1274	25.9	0	21.5	10	2.6	0
Milk	100	250	3.2	0	3.2	204	0.03	0
Total intake	450	2683	34.85	2.3	25.4	249	5.18	1.8

In general, dietary fibre is not present in foods of animal origin. The estimated dietary fibre intake decreases from 12.3 to 2.3 g, which shows the impact of a single error in the calculation of nutrient intake estimations. Therefore, care must be taken when copying or transferring values.

II.E5 In another food composition table, for white boiled rice a Southgate dietary fibre value of 1.0 g/100 g is found and an Englyst dietary fibre value of 0.1 g/100 g. Recalculate the total nutrient intake for both values using the results of II.E4, and discuss the result in relation to the nutrient definition used in the calculation of nutrient intake estimations. *(3 points - ½ point for each correct calculation and 1 point for the explanation)*

Answer:

Food item	Consumption (g)	Energy (kJ)	Protein (g)	Dietary Fibre (g)	Fat (g)	Ca (mg)	Fe (mg)	Vitamin C (mg)
Rice, cooked	200	1086	5.4	2 (Southgate) 0.2 (Englyst)	0.6	20	2.4	0
Carrot, boiled	50	73	0.35	1.5	0.1	15	0.15	1.8
Meat, cooked	100	1274	25.9	0	21.5	10	2.6	0
Milk	100	250	3.2	0	3.2	204	0.03	0
Total intake	450	2683	34.85	3.5 (Southgate) 1.7 (Englyst)	25.4	249	5.18	1.8

Compared with the Prosky dietary fibre value of 0.4 g/100 g, the Southgate dietary fibre is higher and the Englyst fibre much lower. Differences arise in estimating the dietary fibre intake for the meal: 2.3, 3.5 and 1.7 g, respectively. This shows the impact of a single value in calculating nutrient intake. The effect increases as an increasing amount of rice is consumed. This also demonstrates the impact of the definition of dietary fibre on dietary fibre intake, and the importance of verifying the method in the source food composition table or database.

II.E6 In this example, the cooked rice is not white (as assumed) but brown (per 100g: energy 464 kJ, protein 2.6 g, fat 0.9 g, fibre 1.8 g, Ca 10 mg, iron 0.5 mg, vitamin C 0 mg). Recalculate the total nutrient intake taking the nutrient values of brown rice and using the results of II.E4, and discuss the result in relation to errors due to an incomplete food description. *(7 points - ½ point for each correct intake calculation and 1 point for the explanation)*

Answer:

Food item	Consumption (g)	Energy (kJ)	Protein (g)	Dietary Fibre (g)	Fat (g)	Ca (mg)	Fe (mg)	Vitamin C (mg)
Rice, cooked	200	928	5.2	3.6	1.8	20	1	0
Carrot, boiled	50	73	0.35	1.5	0.1	15	0.15	1.8
Meat, cooked	100	1274	25.9	0	21.5	10	2.6	0
Milk	100	250	3.2	0	3.2	204	0.03	0
Total intake	450	2525	34.65	5.1	26.6	249	3.78	1.8

The main difference in nutrient intake estimations relates to dietary fibre, which increases from 2.3 g (or 3.5 g and 1.7 g) to 5.1 g in this meal. This demonstrates that food descriptions and processing effects are important in terms of nutrient values.
For your information

Iron content should be higher in brown rice as more minerals and vitamins are found in the outer layer, which is removed in white rice. It seems that the white rice could be enriched with iron (which ideally should be shown in the food description) or the iron value of the brown rice is incorrectly too low.

II.E7 A user made an error regarding milk because the Ca value from fortified milk was borrowed. The calcium content is 113 mg/100 g in unfortified milk. Recalculate the total nutrient intake using the results of II.E6, and discuss the result in relation to errors due to food fortification and a recommended daily intake of 800 mg/d. *(1.5 points - ½ point for the correct calculation and 1 point for the explanation)*

Answer:

Food item	Consumption (g)	Energy (kJ)	Protein (g)	Dietary Fibre (g)	Fat (g)	Ca (mg)	Fe (mg)	Vitamin C (mg)
Rice, cooked	200	928	5.2	3.6	1.8	20	1	0
Carrot, boiled	50	73	0.35	1.5	0.1	15	0.15	1.8
Meat, cooked	100	1274	25.9	0	21.5	10	2.6	0
Milk	100	250	3.2	0	3.2	113	0.03	0
Total intake	450	2525	34.65	5.1	26.6	158	3.78	1.8

The estimate of the calcium intake decreases from 249 g to 158 mg. With a requirement of 800 mg/d, the adequacy drops from about 31% to 20%. Therefore, care must be taken when borrowing data from foods that might be fortified.

II.E8 Improve the food description of 'milk' and 'meat, cooked' to enhance the quality of food matching between reported foods and foods in the food composition table, which would result in better nutrient values and nutrient intake estimations. For meat and milk, list three descriptors each. *(3 points: ½ point for each correct response)*

Answer:

Your answer should contain any three of the food descriptors for meat and milk:

Meat:
- specify the animal (e.g. chicken, beef, mutton);
- type of cut (e.g. chop, fillet, leg);
- fat content (e.g. lean, medium fat, fatty);
- type of cooking (e.g. boiled, fried, grilled);
- with or without visible fat;
- fat for frying.

Milk:
- specify the animal (e.g. cow, goat, buffalo);
- processing type (e.g. dried, liquid, UHT, pasteurized, sterilized, condensed,
- evaporated, flavoured, sweetened);
- fat content (e.g. whole, partially skimmed, skimmed);
- fortificant(s).

For your information:
The complete food description should be available in both the food composition table and the food consumption report, so that estimates of the nutrient intake correctly represent what a person has consumed.

II.E9 Sixty percent of a population takes vitamin and mineral supplements once a week and 30% of the national food supply is fortified with a number of vitamins and minerals. The food composition database does not contain compositional data on fortified foods or vitamins and minerals supplements. State two consequences for nutrient intake estimations and dietary adequacy. *(2 points: 1 point for each correct response following the dot (•))*

Answer:

(•) Vitamin and mineral intakes are greatly underestimated because the contributions of the vitamin and mineral supplements and/or the fortified foods cannot be taken into account. Therefore, the higher the percentage of the population taking supplements or consuming fortified foods, the greater the underestimation of nutrient intakes may be.

(•) This may have enormous implications for dietary adequacy, i.e. a higher proportion of the population would be estimated to not meet the nutrient requirements compared with the true intake, and consequently inappropriate nutrition guidelines, programmes and policies might be implemented.

(•) A certain percentage of the population may run the risk of exceeding the tolerable upper intake levels (UL), therefore risking adverse health effects due to excessive intakes.

For your information:
Increasingly, population groups have nutrient intakes close to or above the UL and are therefore in danger of suffering from adverse health effects. If food composition databases and tables included more fortified foods, the calculated nutrient estimations would be closer to the true intake and consumers could be better protected from intakes that are above toxicological limits.

GENERAL FEEDBACK USING SELF-SCORING

55 – 75 points: You have understood and integrated the principles for use of food composition data. Congratulations. If you wish to further extend your knowledge in this area you may continue reading the literature as proposed under Suggested additional reading. You are well prepared to proceed to the next module and to apply the new knowledge.

35 – 54 points: You have understood and integrated most of the principles for use of food composition data. This is very encouraging. You could strengthen your knowledge by returning return to the sections where you did not obtain all possible points. It is recommended that you do so in order to effectively apply the new knowledge.

20 – 34 points: You have understood and integrated a fair part of the principles for use of food composition data. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so in order to effectively apply the new knowledge. If you are an analyst, you know enough about users and their requirements concerning food composition data.

0 – 19 points: You appear to have significant gaps in your understanding of the principles for use of food composition data. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

Recommendation: This model may be used to make politicians and decision-aware of the need for high-quality composition data.

Module 3

SELECTION AND NOMENCLATURE OF FOODS IN FOOD COMPOSITION DATABASES

LEARNING OBJECTIVES

By the end of this module the student will be able to:

- select foods for inclusion in a food composition database programme that meets the requirements of different groups of users;
- select foods and nutrients for analysis in a food composition database programme that cover the main foods and nutrients of the national diet (key food approach);
- understand the importance of food nomenclature, including terminology and classification;
- describe foods well in a food composition database;
- grasp the importance of food description and processing (e.g. cooking and inclusion/exclusion of inedible parts) and their effect on nutrient values, specifically on water, fat, minerals and vitamins;
- comprehend food classification and be able to develop one for one's own food composition database.

REQUIRED READING

- **Charrondière, U.R**. 'Food Nomenclature', available at: http://www.fao.org/infoods/presentations_en.stm

and if possible:

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use*. FAO. Rome[6]. Chapters 3 (pp. 33-46) and 5 (pp. 75-78). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf

EXERCISE MATERIALS

- Spreadsheet 'KeyFood exercise.xls', needed for exercise III.E4, is available at http://www.fao.org/infoods/presentations_en.stm. A limited knowledge of Excel is required.
- **Haytowitz, D.B., Pehrsson, P.R. & Holden, J.M.** 2002. The Identification of Key Foods for Food Composition Research. *Journal of Food Composition and Analysis*. 15(2): 183-194. Available at: http://www.nal.usda.gov/fnic/foodcomp/Bulletins/keyfoods.htm
- **Truswell, S.A., Bateson, D.J., Madafiglio, K.C., Pennigton, J.A.T., Rand, W.M. & Klensin, J.C.** 1991. Committee Report: INFOODS - Guidelines for Describing Foods: A Systematic Approach to Describing Foods to Facilitate International Exchange of Food Composition Data**.** Academic Press. *Journal of Food Composition and Analysis* 4, 18-38. Available at: http://www.fao.org/wairdocs/AD069E/AD069E00.HTM
- The LanguaL food description system: its use, thesaurus and further literature, available at http://www.langual.org/. This is also interesting with regard to 'further links' to national food composition databases, for example.

RESOURCES

Taxonomic websites

- http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl
- http://mansfeld.ipk-gatersleben.de/ http://www.plantnames.unimelb.edu.au/Sorting/Frontpage.html
- http://www.seedtest.org/en/home.html
- http://www.fao.org/figis/servlet/static?dom=org&xml=sidp.xml&xp_lang=en&xp_banner=fi
- http://www.fishbase.org/home.htm and http://www.fishbase.org/search.php
- http://vm.cfsan.fda.gov/%7Efrf/rfe0.html

[6] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to the PDF file.

RELEVANCE FOR DIFFERENT GROUPS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts ++

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1-4 hours
- Answering the questions: 1-2 hours
- Completing the exercises: 1-4 hours

Answers to the questions

III.Q1 Is it possible for a food composition database to contain all foods consumed by a population? Select True or False. *(1.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 33):

True	False	Is it possible for a food composition database to contain all foods consumed in a population?
x		No, it is not possible to cover all foods, recipes and brand name foods consumed by a population. Because of their high number, it would be too expensive and time-consuming to include them all in a food composition database. Therefore, foods included in a food composition database will always be a subset of the total foods available for consumption in a country.
x		No, it is not possible to cover all foods, recipes and brand name foods consumed in a population. However, the most important ones, which cover most of the food intake of the population, should be included.
	x	Yes, because only 100, or at most 1,000, foods, recipes and brand name foods are consumed in a population.

For your information:
While it is impossible to cover all foods and components, the archival and reference databases should contain all available data for foods and their nutrients, regardless priorities. User databases or tables should have a selection of those foods and nutrients of interest to the particular user groups. Prioritization involves obtaining new data for relevant foods, by analysis, calculation or estimation, for inclusion in the reference database.

There is increasing recognition of the importance of wild and indigenous foods and of the nutrient compositions of various varieties and cultivars of the same foods. Therefore, these foods should be also included in food composition tables and databases to reflect food biodiversity both in a given country and in their ecosystems.

III.Q2 List the criteria in descending order of importance for prioritizing foods for inclusion in a well-designed national food composition database, i.e. including foods as consumed. Indicate 1 for the most important criteria and 5 for the least important, on the assumption that the main use is for dietary assessment. *(2.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 33-35):

Priority number	Criteria
3	Raw foods and 'Foods as consumed'[7], greatly consumed by specific subgroups (e.g. infants, ethnic groups)
1	Raw foods and 'foods as consumed', greatly consumed by the entire population
5	Foods important for trade or infrequently consumed foods of no particular nutrient interest
4	Foods on the variety/cultivar/breed levels as well as wild, underutilized and indigenous foods
2	Food consumed in small amounts that contribute greatly to the specific nutrient intake of the entire population

[7] 'Food as consumed' means that the food is described in the state in which it is consumed, i.e. brand name foods or foods without inedible part and cooked if applicable, such as boiled rice. Another definition often used in food consumption surveys is 'food as purchased', which means that it is in the state it was bought in, i.e. generally raw and including the inedible part, such as orange or banana with skin.

For your information:
Although some countries give low priority to 'foods as consumed' in their food composition tables and databases, this approach should be encouraged.

III.Q3 The key foods approach is used in the USDA database to prioritize foods to be analysed for certain nutrients. This method utilizes existing nutrient profiles and nationally representative food consumption survey data on consumed foods and recipes. The mean daily food consumption, by the population, of each food including its contribution from recipes, is multiplied by their nutrient content. Emphasis is placed on nutrients of established or potential public health importance. These values are then sorted and ranked from highest to lowest. This step is repeated for all nutrients being examined. Those foods contributing up to a cumulative total of 25% for each nutrient were assigned to the first quartile; those contributing 25–50%, the second quartile; those contributing 50–75%, the third quartile; and those contributing 75–100%, the fourth quartile. Foods in the first three quartiles for each nutrient were defined as the Key Foods.

More information is found in the article of Haytowitz, Pehrsson and Holden (2003), available at http://www.nal.usda.gov/fnic/foodcomp/Bulletins/keyfoods.htm (optional reading).

Answer the following questions: *(4 points: 1 point for each correct response following the dot (•))*

1. How are '**key foods'** defined?
2. What is the purpose of the key foods approach?
3. Which data would you need to identify key foods?

Answer:

1. (•) The key foods approach aims at identifying those foods from the typical diet consumed by the population which contribute significant amounts of nutrients of public health interest (75% of nutrient intake).
2. (•) The key foods approach is used for determining priorities for nutrient analysis in specific foods.
3. The data needed for a key foods approach are (•) food consumption data (or food supply data), indicating the mean amount of foods consumed per day per person together with (•) a rough estimation of their food composition, based on basic nutrition knowledge and/or data from databases (e.g. nutrient values from similar or same foods from national or other food composition databases).

For your information:
The food composition data might be of a preliminary nature, especially in countries without a national food composition database.

It is recommended that a larger number of samples be collected on key foods and that the nutrients thought to contribute most significantly to the diet should be analysed first.

III.Q4 A compiler decides to include the most commonly used recipes in the food composition database. Describe the tasks involved in compiling the recipes with their nutrient values. Use the following headings to describe the different tasks: *(5 points)*

Answer:

(1) Selection of recipes (1 point) – indicate one possible source:

- From a food consumption survey, select the most commonly consumed recipes; **OR**
- Through focus groups representing the different regions and population groups; **OR**
- Select according on the basis of personal knowledge (least optimal solution).

(2) Information on ingredients and preparation methods (1 point) – indicate one possible source:

- From commonly used recipe books or websites; **OR**
- Through focus groups representing the different regions and population groups; **OR**
- Cooks.

(3) Food name and description (1 point) – indicate possible names, including regional or compositional differences:

- Choose a commonly-used recipe name. There are sometimes differences in preparing the same recipe, depending on the region or the individual preference. In this case, add the regions or ingredients in parentheses, thereby making it possible to distinguish between the different recipes.

(4) Presentation of recipe information in a user food composition table – indicate the information provided to the user on the recipe and its ingredients as well as any additional information. *(2 points: ½ point for each correct response following the dot (•))*:

- Present the recipes with (•) all ingredients (including water) (•) in g amount of the edible part of the ingredient. It is desirable to (•) add a very brief description (e.g. fry onions, add other ingredients and boil for 30 minutes) and (•) specify changes in water content during preparation (= yield factor).

For your information:
As water is an ingredient of many recipes, it should be recorded in the appropriate amount. The amount of water in a recipe should correspond either to the amount in the final dish as eaten or to the amount included before cooking. In the latter case, the loss of water should be taken into account by a yield factor. If water is forgotten as an ingredient, the nutrient values of final recipes are too high; and if the water amount before cooking is reported (without accounting for any loss of it during cooking), the nutrient values of recipes are too low.

Water or fat as ingredients in recipes should not be confused with the components 'water' or 'fat, total'.

More information on recipe calculations is provided in module 8.

III.Q5 List the sources of data for food composition tables and databases. Indicate 1 for the most important source and 5 for the least important one. It is assumed that all data sources are available. *(2.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 33-35):

Priority number	Food consumption data sources
4	Food supply data (that is, foods available for human consumption), e.g. national data or FAOSTAT
2	Food consumption data deriving from national household budget surveys
5	Trade statistics
3	Food consumption data deriving from small household budget surveys
1	Food consumption data deriving from national and individual food consumption surveys, e.g. 24-hour dietary recalls, records, food frequency questionnaires

III.Q6 With regard to standardizing or defining food nomenclature in a food composition database, indicate which of the following elements should always be considered as mandatory and which as optional. *(2 points: ½ point for each correct response)*

Answer (see also Greenfield & Southgate, 2003, p. 40):

Food nomenclature element	Mandatory or optional in a food composition database
Food name	Mandatory
Food group	Optional
Food descriptor	Mandatory (or optional if description is considered to be part of the food name)
Food code	Mandatory

For your information:
Food names and descriptions of foods are mandatory because, without them, the food cannot be identified correctly. There is some debate over where the food name ends and the descriptors begin. Some – but not all – nomenclature systems include food groups and/or the food code, which are helpful but not mandatory. Food codes should, however, be included in all food composition tables and databases.

III.Q7 Food groups are defined differently in different countries and regions. Name six generally accepted or widely-used food groups for food composition purposes.
(3 points: ½ point for each correct response)

Answer (see Greenfield & Southgate, 2003, pp. 36-39):

You should have listed six of the following:

- Cereals and cereal products
- Starchy roots and tubers and their products
- Legumes and their products
- Vegetables and their products
- Fruits and their products
- Nuts and their products
- Sugar, sweets and syrup
- Meat and poultry and their products
- Eggs and their products
- Fish and their products
- Milk and their products
- Fat and oils
- Beverages
- Miscellaneous
- Insects and other foods deriving from wild animals

For your information:
Many food composition databases also use subgroups, e.g. for cereals and their products:

- Grains and flour
- Breads
- Pasta
- Prepared foods
- Tortillas
- Sweet biscuits
- Savoury biscuits
- Cakes
- Dough
- Crispbread

- Breakfast cereals

Food groups are often merged if only a few foods of several food groups are consumed, e.g. 'meat, poultry, fish and their products'. Other countries add specific food groups because of their high consumption or owing to the importance of specific foods in their diet, such as coconut products in the Pacific Islands.

III.Q8 Food groups are useful for food composition. Select True or False to explain why food groups are useful in food composition tables and databases. *(3 points: ½ point for each correct response)*

Answer (see also Greenfield & Southgate, 2003, pp. 36-39):

Usefulness of food groups in food composition tables and databases	True	False
To help identify foods in the food composition table database, e.g. for users	x	
To dictate reporting on nutrient intake		x
To serve as a convenient basis for developing a common sampling and analytical plan because of similar food matrix and nutrient values within food groups	x	
To facilitate the compilation and evaluation of data, and to verify the consistency of nutrient values per food group	x	
To conform to the international standard on food grouping		x
To facilitate the application of conversion factors (sometimes done at food group level)	x	

For your information:
There is no globally-accepted standard on food grouping for food composition.

Optional question for those with advanced knowledge or who have participated in a food composition course
III.Q9 Some foods are difficult to place within a given food group in a food composition database or table because grouping depends largely on the local culture. For example: potatoes (or other starchy roots) are difficult to classify because they are sometimes seen as vegetables and other times as tubers. List three foods with similar problems, and indicate which food group they might be placed in. *(3 points: 1 point for each correct response)***.** Think about where you would put them in your country (no points).

Answer:

Possible answers are as follows, but there are many other possibilities.
- Avocado, olives and rhubarb are sometimes considered as fruit and at other times as vegetables;
- Pod vegetables that are consumed fresh and dried, e.g. broad beans, should appear in both the vegetable and legume groups. However, they are sometimes found only in the vegetable group;
- Fruit (vegetable) juices are sometimes grouped under fruits (vegetables) and other times under beverages;
- Marine mammals are considered as both fish and meat;
- Butter is sometimes considered as a dairy product and at other times as fat;
- Salad dressing and mayonnaise are sometimes considered as sauces and sometimes as fat;
- Soya products: e.g. meat replacement soya, could be in the meat and legume group, and soya milk and cheese in the dairy or legume group, etc.;
- Nuts are sometimes with fruits, vegetables, fat and oil, and sometimes in a group of their own;
- Mushrooms are sometimes grouped with vegetables and, at other times, are in a group of their own;
- Cakes are grouped as cereals or as sweets and confectionery, or in their own group.

III.Q10 Select the statements that favour the standardization of food groups both for the presentation of food consumption data and for food composition databases. *(2 points: ½ point for each correct response)*

Answer (see also Greenfield & Southgate, 2003, p. 37):

Reasons for standardizing food groups for food consumption survey data and food composition databases	True	False
Users of food composition tables and databases can always, by means of the index, find the foods they are interested in.	x	
National compilers can only work within their own food grouping systems (country-specific food groups and subgroups) because of their specific food consumption pattern.		x
Food consumption at food group level can only be compared if foods are classified in the same food groups.	x	
Some coefficients (e.g. nutrient retention factors) are applied at the food group level.	x	

For your information:
The standardization of food groups is more important for the presentation of food consumption data than for food composition databases. For the presentation of results of food consumption surveys, it is also important to standardize the state/form of foods, e.g. if consumed cooked or raw (for instance, boiled rice is three times the weight of raw rice), with or without the inedible part, etc. Without this standardization, food consumption reporting can be misleading or be misinterpreted.

III.Q11 Name the two internationally used food description systems (see also http://www.fao.org/infoods/nomenclature_en.stm) *(1 point –½ point for each correct response)*

Answer:

1. INFOODS
2. LanguaL

III.Q12 Define briefly a food facet and a food descriptor. *(2 points: 1 point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 43-44):

Food facet: Facets are categories of food descriptors, e.g. cooking methods.

Food descriptor: A food descriptor is an attribute used to clearly identify a food and its preparation, e.g. boiled. It is like a subgroup of the facet.

For your information:
Food facets and descriptors are used to describe foods more precisely and in a standardized way. Facets and descriptors may be coded and therefore become language-independent. Normally, descriptors come with a thesaurus by which they are defined, thereby facilitating identification and international interchange of data. Food descriptor systems are INFOODS (food facets and descriptors are listed and briefly described) and LanguaL (with defined thesaurus).

III.Q13 'Cooking methods' is one of the major food facets and a corresponding descriptor is 'raw'. Describe the following cooking methods and their effect on water, fat, minerals and vitamins: *(5 points: 1 point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 41-42):

a) **Boiling:** Cooked by immersion in boiling water and separated by draining. Loss or gain of water. Loss of fat, water-soluble and heat-labile micronutrients. Uptake of salt.
b) **Baking:** Cooked by dry heat in oven. Loss of water, (fat) and heat-labile micronutrients. Concentration of components owing to water loss.
c) **Roasting:** Cooked by dry heat with or without the addition of fat. Loss of water and micronutrients; and loss or gain of fat. Concentration of components owing to water loss.
d) **Deep frying:** Immersed in hot fat. Loss of water, micronutrients and intrinsic fat, and gain of fat from frying medium. Concentration of components owing to water loss.
e) **Cooking:** This can be any cooking method that has an effect on water, fat and micronutrients. This is not a recommended descriptor.

For your information:
Fatty foods might lose fat when boiled or grilled.

III.Q14 Explain why the following names should be included in a reference food composition database. *(4 points: 1 point for each correct response)*

Answer:

1. Short names are abbreviations used in the food composition database. They are usually of less than 60 characters. The short name is useful in databases when space per data field is an issue.
2. Long names (about 200 characters) include all information spelled out fully, which is important for correct identification of the food. The long name normally appears in printed food composition tables.
3. Scientific names are taxonomic or Latin names, mostly used for plant foods. They are useful for identifying the food more specifically, i.e. species and if applicable subspecies, varieties, cultivars or breeds of animals. They are particularly relevant for international interchange and use.
4. English food names are often included in food composition databases for international interchange and use.

For your information:
All these names should appear in a food composition database and most of them in a printed food composition table. For the convenience of users, short and long names should be reported in the major local languages. In countries with several national languages, it is necessary to have different name facets for the major languages. They are often listed in indexes.

Some countries put all food name information into the food name field. Others use faceted food names and descriptors, although a faceted system facilitates auditing of a database (e.g. percentage of cooked and raw foods). Both systems are correct.

III.Q15 Many food composition databases and tables include mainly raw foods while others include additionally foods as purchased and/or as consumed. For the following statements, indicate 1 or 2. *(5.5 points: ½ point for each correct response)*

1 = for food composition tables with mainly raw foods
2 = for food composition tables with raw foods, foods as purchased and/or as consumed

Answer:

Put 1 or 2	Statements
1	When 'foods as consumed' are missing in food composition tables, users are obliged to invent their own calculation systems and to borrow data from other countries, which may result in lower-quality nutrient intake estimations.
1	Users often apply the nutrient values of raw foods to prepared foods, which leads to major errors in nutrient intake estimations.
2	Compilers have more knowledge of foods, food preparation and compilation than users. They are therefore in a better position to calculate and estimate good-quality nutrient values of foods as consumed and of recipes.
1	Compilers include only raw foods as they are more stable in composition compared to prepared foods and recipes.
1	For users, this type of table means higher costs and more work for them.
1	Compilers are not aware of users' difficulties if the food composition table contains mainly raw foods.
2	For compilers, this type of table means higher costs and more work for them.
2	This leads to better-quality nutrient intake estimates.
1	This is not very useful for users seeking data on 'foods as consumed'.
2	This leads to lower data quality overall because more data are derived or calculated.
2	This is an improvement for users seeking data on prepared foods, such as canned, take-away, frozen and brand name foods.

III.Q16 Give four examples of inedible parts of fruit, vegetable, fish or meat. *(2 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 43):

Your answer should include any four of the following: bones, skin, peels, core, brine, connective tissue, seeds, fish head, fins, rind, shell, etc.

III.Q17 Which part of the food should be analysed? Select the correct response. *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 40):

	Part to be analysed
	The total food should be analysed because this is the way in which it is consumed.
	The inedible part should be analysed because it contains most of the nutrients.
x	Only the edible part of the food should be analysed because food composition tables and databases contain nutrient values per 100 g edible food.

III.Q18 Indicate the correct statements about edible coefficients and their description. Select True or False. *(2.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 40):

True	False	Edible coefficients:
	x	are independent of culture and individual choice and therefore do not need to be included in food composition tables and databases.
x		are part of a good food description.
x		facilitate correct food matching.
	x	are optional because nutrient values are the same for any given food, with or without inedible part.
x		are needed to transform the weight of foods as purchased to the edible parts of the food.

III.Q19 In the reference database, the description of a sampled and analysed food is complete only once all information on the sample has been added correctly. In the following table, indicate which food description is added at either the sample collection or sampling handling stage. *(10 points: ½ point for each correct response per descriptor)*

Answer (see Greenfield & Southgate, 2003, pp. 75-78):

Food identification and description	Food identification and descriptions are added at:	
	Sample collection	Sample handling
Sample code	x	
Food name	x	
Scientific name	x	
Brand name	x	
Season	x	
Sampling location	x	
Weight and nature of edible part		x
Weight and nature of inedible part		x
Maturity	x	
Part of the food	x	(x)
Physical state, e.g. liquid, solid	x	
Food processing method for processed food	x	
Food processing method for collected raw food which are processed before analysis		x
Weight before and after cooking		x (if food is cooked)
Food preservation method	x	
Packing medium	x	
Packing material	x	
Date of expiry/expiration	x	
Digital photograph	x	x (if food is cooked)
Composite sample preparation		x

For your information:
The reference database should include all the above-mentioned food description fields. When samples are composited, they receive a new sample code and name.

SAMPLE ANSWERS TO THE EXERCISES

III.E1 Match the foods from the food consumption survey below with the foods found in the food composition table, also given below. In some cases, several foods from the food composition table can be matched to a single food from the survey, e.g. tea with milk and sugar = 1 + 2 + 3 (or 4, 5 or 6). *(11 points: 1 point for each correct response)*

Foods from the food consumption survey:
a. Tea with milk and sugar
b. Pork chop, grilled, the visible fat not consumed
c. Chicken breast, roasted, skin not consumed
d. Tomato, grilled
e. Aubergine (eggplant), fried in olive oil
f. Rice, red, fried
g. Rice, white, boiled
h. Mutton in sauce
i. Mixed vegetables, boiled
j. Mango, dark orange flesh, very ripe
k. Chocolate bar, Mars

Foods from the national food composition table:
1. Tea
2. Sugar
3. Low-fat milk
4. Standard milk
5. Semi-skimmed milk, fortified
6. Milk powder, full fat
7. Pork, lean
8. Pork, medium fat
9. Pork, fat
10. Chicken
11. Chicken, dark meat
12. Chicken, light meat
13. Chicken, grilled
14. Chicken, grilled, bones in
15. Mutton, fat
16. Tomato
17. Aubergine (eggplant)
18. Vegetable oil
19. Rice
20. Rice, boiled
21. Spinach
22. Carrot
23. Mango
24. Tap water
25. Chocolate bar

Answer:

(a) Tea with milk and sugar: 1+2+3 (or 4 or 5 or 6). It is not clear whether the tea is liquid or in the form of leaves or powder. In the survey, the type of milk is not specified; nor is the amount of each ingredient.

For your information:
The precision of food descriptions in the survey should be improved. The nutrient values will be only a rough estimate.

(b) Pork chop, grilled, the visible fat not consumed – 7 (or 8). There are differences between raw and grilled. 8 is correct if the pork chop is very fatty, and trimming of the visible fat makes it medium-fat.

For your information:
Some foods, such as different pork cuts or cooking methods, are missing from the food composition table. This leads to underestimating nutrient intake estimations.

(c) Chicken breast, roasted, skin not consumed – 12 or 13 (+18). 'Chicken, light meat' corresponds to chicken breast. However, from the description in the food composition table, it is not clear whether it is raw or cooked in some way. 'Chicken, grilled' can be a mixture of dark and light meat, and there is no indication whether it is with or without skin. The foods in the food composition table can only be an approximation of the nutrient values of the food consumed.

(d) Tomato, grilled – 16. In the food composition table, it is not specified whether the tomato is raw or cooked.

For your information:
Grilling tomatoes results in water loss. Therefore, the application of supposedly raw tomato will result in an underestimation of nutrient values.

(e) Aubergine, fried in olive oil: 17+18. In the food composition table, it is not specified whether the aubergine is raw or cooked.

For your information:
As frying aubergines results in water loss, the application of supposedly raw aubergine will result in an underestimation of nutrient intake. Vegetable oil is that which is most similar to olive oil. If the fatty acid profile is important and fried aubergine is highly consumed the substitution will introduce errors in the fatty acid intake estimations.

(f) Rice, red, fried: 20+18 (or 19+24+18). Boiled red rice is similar to boiled white rice even though the water content is slightly lower. It is not clear whether the rice in the food composition table is white. Red rice has a higher content of dietary fibre and of other nutrients. Fat needs to be added for frying. No information on the type of fat is available from the survey.

(g) Rice, white, boiled: 20. This would be an exact food match if the 'boiled rice' in the food composition table was really 'white rice'.

(h) Mutton in sauce, one possibility**:** 15+18+22+24. The survey contains insufficient information on the ingredients. For this recipe, there are no onions or potatoes in the food composition table. Mutton might be too fat. The mutton in the food composition table is supposed to be raw. Water should not be forgotten in the recipe. If the sauce is not consumed the nutrient content of the consumed part of the recipe is different.

For your information:
This implies a high risk of error in nutrient intake estimations.

(i) Mixed vegetables, boiled: 16+17+22 (+21). The survey contains insufficient information on the ingredients. Vegetables are supposed to be raw in the food composition table but in the survey they are boiled. This will lead to an underestimation of nutrient intake because of water loss of most vegetables, and loss of minerals and vitamins due to leaching into the water and heat processing.

(j) Mango, dark orange flesh, very ripe: 23. The food composition table gives insufficient information on mango.

For your information:
If the mango in the food composition table is not dark orange and not very ripe, the intakes of carotenes will be seriously underestimated.

(k) Chocolate bar, Mars: 25 is an approximation.

III.E2 Take six foods from the food composition table listed in III.E1 and improve the food descriptions, e.g. chocolate = chocolate, powder, 70% cacao. *(3 points: ½ point for each food description)*

Answer:

Your answer might include any six of the following improved food descriptions. However, these are only examples – there are many other possible correct answers:

1. Tea, *black liquid*
2. Sugar, *white*
3. Low-fat milk, *1.5% fat*
4. Standard milk, *3.5% fat*
5. Semi-skimmed milk, fortified *with calcium and vitamin D*
6. Milk powder, full-fat
7. Pork, lean, *raw*
8. Pork, medium fat, *raw*
9. Pork, fatty, *raw*
10. Chicken, *whole, raw*
11. Chicken, dark meat, *raw*
12. Chicken, light meat, *raw*
13. Chicken, *whole,* grilled
14. Chicken, *whole,* grilled, bones in
15. Mutton, fatty, *raw*
16. Tomato, *raw*
17. Aubergine, *raw*
18. Vegetable oil, *blend of corn and soya*
19. Rice, *white, raw*
20. Rice, *white*, boiled
21. Spinach, *raw*
22. Carrot, *raw*
23. Mango, *yellow, ripe*
24. Tap water
25. Chocolate bar, *Mars type*

For your information:
A food description must be comprehensive enough to allow for an unambiguous identification of the food, i.e. all food descriptors influencing the nutrient values of the food should be included. Any omission of an essential food descriptor will result in varying interpretations of what the food represents, leading to different estimates of food and nutrient intakes.

III.E3 Exercise on key food approach (adapted from Machteld van Lieshout). Select the key foods for iron, which contribute 75% of the iron intake, from the foods listed in the Excel file 'KeyFood exercise.xls'. The Excel file is available at: http://www.fao.org/infoods/presentations_en.stm.
(8 points: 2 points for each correctly selected key food)

Instructions for using Excel file 'KeyFood exercise.xls' for this exercise:
The 'KeyFood exercise.xls' file has four worksheets: 'Cons and Comp' (where you find the consumption and composition data of the food consumed), keyFoods protein (an example on the identification of key foods for protein), keyFoods iron (where you should select key foods for iron), and keyFoods fat (where you should select key foods for fat if you wish to do a supplementary exercise). To do this exercise, you need both to have access to Excel and some experience in using it. If you do not have such access, you can do the exercise on paper (although it will take much more time).

Note:
- If you are not very familiar with Excel, you might find it helpful to consult 'Excel help'; which is available at http://office.microsoft.com/en-us/excel/FX100646951033.aspx
- The compositional data are derived from the South African Food composition tables.

Logical steps
1. Calculate for each food the nutrient intake (food intake times nutrient content).
2. Calculate the total nutrient intake by summing the nutrient intakes of all foods.
3. Calculate the cumulative % of each food to the total nutrient intake.
4. Order the foods in descending order of contribution.
5. Select the foods contributing 75% of the nutrient intake.

Steps to be followed for iron:
- Copy the worksheet 'Cons and Comp' into the worksheet 'keyFoods iron': In the 'Cons and Comp' worksheet, click on upper left cell to select the whole worksheet and then Ctrl+c for copying. Go to worksheet 'keyFoods iron' and press the upper left cell and then Ctrl+v to paste the data into the worksheet 'keyFoods iron';
- Delete the columns you do not need. Keep the columns with the headings: code, Food item; Mean food intake in g/p/d; Iron in mg/100 g;
- Add the following columns: Iron intake in g/p/d; %from iron intake from food; Cumulative %intake;
- In column E (Iron intake in g/p/d) calculate iron intake per food: Mean food intake in g/d/p x Iron in mg/100 g, i.e. put the following formula in E2: =C2*D2/100 (do not forget = in front of the formula nor to divide by 100 – the latter is done because the iron value is per 100 g food). Copy cell E2 with its formula to cells E3 to E18;
- In column E (Iron intake in g/p/d), calculate the total iron intake by summing up the iron intakes per food: go to cell E19 and press the sum sign from the tool bar ∑;
- In column F (%from iron intake from food), calculate the percent of each food of the total iron intake: put into cell F2 the formula =E2/$E$19*100 (the dollar signs are necessary to tell the computer that it always should look at cell E19; and dividing by 100 gives the percentage). Copy cell F2 with its formula to cells F3 to F18;
- Determine the order of the data in the **whole** worksheet according to %from iron intake from food: Select the cell in the left upper corner (=select whole worksheet), then in toolbar select "Data" and then 'Sort'. Choose '%from iron intake from food' (to select the column according to which all data should be sorted) and select 'Descending' (so that data will be sorted with highest number first);
- In column G (Cumulative %intake), calculate the cumulative %intake of each food. Put in G2 the value of F2 and put into G3 the formula =G2+F3. Copy cell G3 with its formula to cells G4 to G18;
- Select all foods as key foods for iron that contribute to 75% of the iron intake.

Answer:

For iron

Code	Food item	Mean food intake in g/p/d	Iron, mg/100g	Iron intake in g/p/d	%from iron intake from food	Cumulative % intake	
2	Brown bread	91	1.5	1.365	28.7	28.70	Key food for iron
1	Cooked maize porridge	661	0.2	1.322	27.7	56.4	Key food for iron
8	Beef steak – fillet, sirloin/rump	17	3.3	0.561	11.8	68.2	Key food for iron
3	White bread	45	1.2	0.54	11.3	79.6	Key food for iron
7	Chicken meat – drumstick, thigh, breast	21	1.3	0.273	5.7	85.3	
11	Mutton	10	1.8	0.18	3.8	89.1	
12	Fat cakes	9	1.2	0.108	2.3	91.3	
14	Fish – fresh, fried	7	1.1	0.077	1.6	93.0	
16	Cookies or cakes	4	1.9	0.074	1.6	94.5	
15	Beef offal	6	1.2	0.072	1.5	96.0	
9	Grapes, fresh	15	0.3	0.045	0.9	97.0	
6	Boiled white rice	22	0.2	0.044	0.9	97.9	
4	Full-cream liquid milk	38	0.1	0.038	0.8	98.7	
10	Apple, fresh	11	0.3	0.033	0.7	99.4	
13	Peach, fresh	8	0.4	0.032	0.7	100.0	
5	Beer	32	0.0	0	0.0	100.0	
17	Spirits	4	0.0	0	0.0	100.0	
				4.764			

For your information:
Special attention must be paid to foods which may be enriched or fortified.

The result for selected key foods for fat intake is given below.

Code	Food item	Mean food intake in g/d/person	Fat, g/100 g	Fat intake in g/p/d	% from fat intake from food	Cumulative % intake	
1	Cooked maize porridge	661	0.6	3.966	20.2	20.20	Key food for fat
8	Beef steak – fillet, sirloin/rump	17	17.2	2.924	14.9	35.1	Key food for fat
7	Chicken meat – drumstick, thigh, breast	21	13.6	2.856	14.5	49.6	Key food for fat
11	Mutton	10	23.1	2.31	11.8	61.4	Key food for fat
2	Brown bread	91	2.0	1.82	9.3	70.6	Key food for fat
12	Fat cakes	9	17.7	1.593	8.1	78.7	Key food for fat
4	Full-cream liquid milk	38	3.3	1.254	6.4	85.1	
14	Fish – fresh, fried	7	14.0	0.98	5.0	90.1	
3	White bread	45	1.8	0.81	4.1	94.2	
15	Beef offal	6	11.2	0.672	3.4	97.6	
16	Cookies or cakes	4	9.2	0.366	1.9	99.5	
6	Boiled white rice	22	0.3	0.066	0.3	99.8	
9	Grapes, fresh	15	0.1	0.015	0.1	99.9	
10	Apple, fresh	11	0.1	0.011	0.1	100.0	
13	Peach, fresh	8	0.1	0.008	0.0	100.0	
5	Beer	32	0.0	0	0.0	100.0	
17	Spirits	4	0.0	0	0.0	100.0	
				19.651			

III.E4 Select two of the following foods and find their taxonomic names through the websites indicated under Resources. *(4 points: 2 points for each correct response)*

Answer:

a) Mango: Mangifera indica L (http://mansfeld.ipk-gatersleben.de/pls/htmldb_pgrc/f?p=185:55:471266269466518::NO::P7_COMMONNAME:mango;
b) Herring: e.g. Clupea harengus harengus (http://www.fishbase.org/search.php);
c) Spinach: Spinacia oleracea L (http://mansfeld.ipk-gatersleben.de/pls/htmldb_pgrc/f?p=185:55:2625726202107630::NO::P7_COMMONNAME:spinach or http://www.ars-grin.gov/cgi-bin/npgs/html/tax_search.pl);
d) Red kidney bean: no result found, only for kidney bean: Phaseolus vulgaris subsp. vulgaris (http://mansfeld.ipk-gatersleben.de/ or http://www.plantnames.unimelb.edu.au/Sorting/Flageolet.html or http://www.ars-grin.gov/cgi-bin/npgs/html/tax_search.pl).

III.E5 The objective of a 24-hour recall survey is to estimate the intake of fat and fatty acids to correlate them to the risk of breast cancer. The questionnaire should therefore collect highly detailed information with regard to fat. What kind of data should be available in the food composition table or database? Think about two main levels: nutrients (e.g. saturated or unsaturated fatty acids) and foods (e.g. cooking method, processing). *(7 points: 1 point for each correct response following the dot (•))*

Answer:

Nutrient data needed (indicate three)

- Fat, total;
- Fatty acid fractions: saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, *trans* fatty acids;
- Individual fatty acids including cis and *trans* isomers (see the INFOODS tagnames for fatty acids, available at: http://www.fao.org/infoods/tagnames_en.stm).

Food coverage and description needed (indicate four)
Your answer should include any four of the following:

- Include raw and cooked foods with different cooking methods (especially fried foods with the different fats used for cooking);
- State whether the food is with or without visible fat (for meat and meat products), or with or without skin (for fish and poultry);
- List different meat cuts (they help to identify the different fat contents);
- Include fat content (e.g. % fat in milk of dairy products or meat cuts);
- Include processed foods (e.g. tuna in oil or brine), and include brand names where necessary (e.g. margarines have different fatty acid profiles and should be taken into account for countries with a high consumption of margarine. However, it is very difficult to obtain the individual fatty acid composition from manufacturer's because the oil source, and thus the composition for margarines changes according to price);
- Ideally, include the individual recipes with the different fats used, as reported by subjects from food consumption surveys, ;
- Include keyfoods for fat and fatty acids.

Optional question for those with advanced knowledge or who have participated in a food composition course
III.E6 Select two of the following foods and list the codes of the LanguaL food description system (available at http://www.langual.org/) and codes and descriptors of the INFOODS system (available at http://www.fao.org/infoods/nomenclature_en.stm). When using LanguaL, consult the definition displayed at the top of the screen. Do not use the Eurocode 2 classification. *(8 points: 2 points for each correct response)*

Note: It might be useful to download the LanguaL Food Product Indexer, version 3.91. Available at: http://www.langual.org/langual_downloads.asp

The objective of this exercise is to experience the different food description systems.

Answer:

Food	LanguaL	INFOODS
Mango (Kiew-sa-weya), unripe; raw, Mangifera indica found in the ASEAN food composition table, published in 2000	A0833 (or A0143 or A0707), B1270, C0229, E0150, F0003, G0003; H0003; J0003, K0003, M0003, N0001, P0024, R0001, Z0051. It was not possible to indicate Kiew-sa-weya	A: ASEAN food composition table, 2000. B. Name: B1: Kiew-sa-weya (Thai); B3: Mango; B6: Fruits and products; C1: Mangifera indica; C6: raw; C10: unripe; C14: whole flesh
Pork chop, without visible fat, grilled	A0794 (or A0714 or A0150 or A076), B1136, C0266, E0150, F0014, G0006; H0161 (or Z0106); J0003, K0003, M0003, N0001, P0024, R0001. It was not possible to indicate chop	B1/C2: Pork chop; C6: grilled; C16: without visible fat
Kellogg's cornflakes, fortified	A0768 (or A0816 or A0258), A0729, A0457, B1379, C0155, E0153, F0022 (or F0014), G0001, H0194, (The following information is only found on the product label but is not available in the food description: H0100, H0138, H0158, H0181, H0215, H0216, H0274, H0309, H0310, H0311, H0316), J0001 (or J0144, J0116, J0151), K0003, M0213 and/or M0155, N0036, P0024, R0001, Z0112 (optional). It was not possible to indicate Kellogg's	B1: Cornflakes; C4: Kellogg's; C16 fortified
Porridge, made of oatmeal, full-fat milk and sugar found in Granny's cookery book, published in 2007. The porridge is made of full-fat milk (500g), 6g oatmeal (60g), white sugar (20g); it is boiled for 15 minutes	A0816 (or A0692 or A0139 or A0106), B1219, C0155, E0121 or E0138, F0014, G0018; H0184; H0158, J0003, K0003, M0003, N0003, P0024, R0001. It was not possible to indicate that it is a recipe and that the milk is full-fat	B1: Porridge, made of oat meal, full fat milk and sugar; D1: full fat milk (500g), 6g oatmeal (60g), white sugar (20g); D1a: Granny's cookery book, 2007; D2: boil for 15 minutes

For your information:
This exercise shows that it is difficult to use either food description system without additional instructions, especially LanguaL, which is highly sophisticated.

GENERAL FEEDBACK USING SELF-SCORING

71 – 102.5 points: You have understood and integrated issues on food selection and nomenclature of foods in food composition databases. Congratulations. You are well prepared to proceed to the next module and are capable of selecting the right foods for food composition programmes.

47 – 70 points: You have understood and integrated most of the issues on food selection and nomenclature of foods in food composition databases. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so in order to effectively apply the new knowledge.

24 – 46 points: You have understood and integrated a fair part the issues on food selection and nomenclature of foods in food composition databases. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

0 – 23 points: You appear to have significant gaps in your understanding of issues food selection and nomenclature of foods in food composition databases. You should read the sections again and improve your knowledge of these topics. This is highly recommended that you do so in order to effectively apply the new knowledge.

Module 4.a

COMPONENT SELECTION

LEARNING OBJECTIVES

By the end of this module the student will be able to:

- understand the process of selecting food components for a national food composition database;
- select components for inclusion in archival, reference and user databases[8].

REQUIRED READING

- **Charrondière, U.R**. 'Selection of Nutrients and other Components', available at: http://www.fao.org/infoods/presentations_en.stm

and if possible:

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use.* FAO. Rome. Chapters 1 (pp. 10-12[9]), 2 (pp. 24-25), 4 (pp. 47-62), 7 (pp. 117, 144-145) and 11 (pp. 179–181 and 191-192). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts +

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1-4 hours
- Answering the questions: 1-2 hours
- Completing the exercises: 1-3 hours

[8] For an explanation of these terms, see pp. 10-12 of Greenfield & Southgate (2003).
[9] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to the PDF file.

Answers to the questions

IVa.Q1 Who should discuss the components to be included in a food composition database? Select True or False. *(3 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 24-25):

Discuss component inclusion	True	False
Government institutions	x	
Analysts	x	
Consumers		x
Users	x	
Industry	x	
Compilers	x	

IVa.Q2 List three considerations that govern the selection of components for food composition tables and databases. *(3 points: 1 point for each correct response)*

Answer: (see Greenfield & Southgate, 2003, p. 47)

Your answer should include any three of the following:

- Considered as basic data, i.e. macronutrients and energy;
- Recommended daily intake (RDI) exists for the nutrient;
- Components related to public health problems in the country concerned;
- Required to calculate other components, including conversion factors;
- State of current thinking in the nutrition and toxicological sciences;
- Availability of existing data;
- Existence of adequate analytical methods;
- Feasibility of analytical work;
- National and international regulations on nutrition labelling;
- Availability of funds.

For your information:
Although Greenfield and Southgate (2003) does not specifically indicate that components with RDI should appear in food composition tables and databases, their inclusion makes it possible to assess dietary adequacy in the country.

Contributing components needed to calculate certain components should be also included in the database, together with their conversion factors if such factors exist. Examples: all energy-yielding components with their energy conversion factors for energy, or retinol and carotenes with provitamin A activity and their conversion factors for vitamin A.

IVa.Q3 Why do user food composition tables and databases not include all the components that users consider appropriate? Indicate True or False. *(3 points: ½ point for each correct response)*

Answer (see also Greenfield & Southgate, 2003, pp. 47, 191-192):

Why user food composition tables and databases do not include all components of interest for users	True	False
Lack of funds for food analysis and data compilation	x	
Poor knowledge of user requirements	x	
Insufficient space in reference database		x
No existing analytical methods for certain food components	x	
Lack of knowledge of obsolete food component definitions (e.g. crude fibre is obsolete and should not be used in food composition tables and databases)	x	
Lack of one's own laboratory facilities		x

IVa.Q4 Should water be included in every food composition database level, i.e. in archival, reference and comprehensive user databases? Select the correct response. *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 52):

☒ Water should be included in every food composition database because it serves as a reference point for other food component values.

☐ Water should not be included in every level of the food composition database because it has no energy value and is not important for nutrient intake estimations.

For your information:
Water should be part of archival, reference and comprehensive user databases but should not necessarily be part of a concise (or abridged) user database.

Water is used to:
- correctly identify foods (e.g. dry foods should have a lower water value than corresponding fresh foods);
- compare foods (ascertain whether water values are similar – differences in water content can explain differences in other nutrient values);
- check that aggregated foods have a similar water content – if water contents are significantly different, the other nutrient values should be adapted before aggregating the foods with their nutrient values);
- check if the data are expressed on fresh or dry matter basis.
- calculate the nutrient values per 100 g of edible food when, in the literature, nutrient values were reported on dry matter basis.

IVa.Q5 Why should total nitrogen be included in the reference food composition database? *(1 point)*

Answer (see Greenfield & Southgate, 2003, pp. 52-56):

Total nitrogen should be included, both because it is the analytical value reported by the laboratory and because it is needed to calculate the protein value.

For your information:
Total nitrogen should be part of archival, reference and comprehensive user databases but should not necessarily be part of a concise (or abridged) user database. Some food composition databases also include protein nitrogen values.

IVa.Q6 Give one reason for including ash values in the food composition database. *(1 point)*

Answer (see Greenfield & Southgate, 2003, pp. 53, 61):

Your answer should be one of the following:
- Ash values are needed to calculate total or available carbohydrates by difference.
- Ash is needed to ascertain whether the sum of the proximates is equal to 100 g (while the range of 97-103 g is considered acceptable).
- Ash is an approximation of the sum of minerals and may be used to check whether the sum of minerals is close to the ash value.

For your information:
Ash should be part of the archival, reference and comprehensive (unabridged) user databases but not necessarily be part of the concise (abridged) user database.

IVa.Q7 Concise (abridged) user food composition tables and databases are intended for use by lay persons and groups with limited requirements in terms of nutrient values. The comprehensive (unabridged) user food composition database is aimed more at researchers with more requirements, i.e. with regard to nutrients and components, foods and metadata information. Select the food components that are not normally included in the comprehensive use database. *(8.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 51-55):

	Food components included in the comprehensive user database	Food components NOT included in the comprehensive user database
Energy conversion factors	x (in introduction)	
Water	x	
Non-protein nitrogen		x
Sucrose	x	
Dietary fibre	x	
Lignin		x
Alcohol	x	(x) in many Muslim countries
Fat	x	
Individual fatty acids	x	
Phospholipids		x
Iron	x	
Vitamin C	x	
Vitamin B_{12}	x	
Individual carotenes	x	
Vitamin D	x	
Additives	x	
Phytoestrogens	x	

For your information:
The comprehensive user database may include most of the reference database components. However, as a general rule, components are only included in the comprehensive user database if data are available for most of its foods, meaning that missing values are minimized.

Both types of user food composition databases are generated from the same reference database, which normally holds many more food components, foods and much more documentation than user databases.

IVa.Q8 Conversion factors are needed to calculate some nutrient values, e.g. they convert a component quantity into energy or into a vitamin activity. Established conversion factors may, however, change over time. Where and how should conversion factors be stored in the food composition database so that nutrient values can be easily recalculated using the new conversion factors? Indicate True or False. *(1 point: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 180-181):

Where and how to store conversion factors	True	False
Conversion factors and their values should be stored in the reference database, preferably in the same way as components and their values, so that nutrient values can be easily recalculated using the new conversion factors.	x	
Conversion factors and their values should not be stored in the food composition database. It is sufficient to state them in the introduction to the food composition tables and databases.		x

For your information:
Just like components, conversion factors have numerical values. As such, ideally they should be stored in the same way as components, i.e. the conversion factor names in the 'component name' file and their values in the 'component value' file. In this way, only the component and component value files will have to be queried in order to calculate the corresponding nutrient value. If conversion factors and their values were stored at food level, another file is needed for calculations.

IVa.Q9 Which components are necessary to calculate vitamin A values? *(4.5 points: ½ point for each correct response)*

Note:
- Total vitamin A activity expressed as retinol equivalent (RE) in mcg = mcg retinol + 1/6 mcg β-carotene + 1/12 mcg other provitamin A carotenoids (or RE =mcg retinol + 1/6 mcg β-carotene equivalent where β-carotene equivalents = 1 β-carotene + 0.5 α-carotene + 0.5 β-cryptoxanthin);
- Retinol activity equivalent (RAE) in mcg = mcg retinol + 1/12 mcg β-carotene + 1/24 mcg other provitamin A carotenoids (or RE =mcg retinol + 1/12 mcg β-carotene equivalent where β-carotene equivalents = 1 β-carotene + 0.5 α-carotene + 0.5 β-cryptoxanthin).

Answer:

Food components	Needed to calculate vitamin A	Expressions of vitamin A
Retinol	x	
Retinol activity equivalent (RAE)		x
ß-carotene equivalent	(x)	
ß-carotene	x	
α-carotene	x	
Retinol equivalent (RE)		x
ß-cryptoxanthin	x	
Lycopene		
Conversion factors (α- and ß-carotenes, ß-cryptoxanthin)	x	

For your information:
ß -carotene equivalent is not needed if all contributing nutrients are in the database.

Optional question for those with advanced knowledge or who have participated in a food composition course
IVa.Q10 In a scientific article, a compiler finds component values not of current interest, i.e. not in the user database. What should the compiler do? *(1 point)*

Answer:

☐ Archive only those food component values that are considered of interest today. In the event they become of interest at a later date, they can be easily archived in the future.

☒ Archive all food component values (including those not considered of interest today) into the archival and reference database because they might become of interest and be published in future user databases.

IVa.Q11 In theory, food composition databases may contain chemical contaminants. Name three types of contaminants. *(1.5 points –½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 49):

Your answer should include any three of the following:
- Heavy metals, e.g. cadmium, lead, mercury
- Herbicides
- Pesticides
- Dioxins
- Polychlorinated biphenyls (PCBs)
- Radionucletides
- Drug residues

This list might not be complete.

IVa.Q12 Some food composition databases include antinutrients. Define antinutrients and name three. *(2.5 points - 1 point for the definition + ½ point for each of the three antinutrients)*

Answer (see Greenfield & Southgate, 2003, p. 61):

Definition of antinutrient:
An antinutrient inhibits the activity of a nutrient and may thus lead to undesirable physiological effects, such as nutrient deficiencies.

Examples of antinutrients:
Your answer should include any three of the following:
- Goitrogens
- Haemagglutinins
- Antivitamin factors
- Trypsin inhibitors
- Oxalic acid
- Phytic acid (phytates)
- Tannin (decreases non-hem iron absorption)

For your information:
Although many users need data on antinutrients, they are provided in very few user databases. However, users would appreciate to find them in food composition databases. Data on phytates may be found in the World Food Software Program, for example (available at: http://www.fao.org/infoods/software_worldfood_en.stm)

IVa.Q13 Give two reasons for, and two against, the inclusion of contaminants and antinutrients in food composition databases and tables. *(4 points: 1 point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 61):

Reasons why chemical contaminants and antinutrients should not be included:
Your answer should include any two of the following:

- In general, analysing contaminants is expensive and calls for sophisticated equipment.
- The analysis of contaminants and nutrients is normally carried out by different organizations;
- Compilers are not aware of user needs, especially concerning antinutrients.
- Contaminants are more dependent on time and specific batches. This makes it more difficult to report them as a year-round average, as is normally done for nutrients. Nutrients are considered to be less variable.
- Food sampling designs may differ for contaminants and nutrients. Most contaminant data are derived from monitoring surveys aimed at identifying and monitoring food with potentially high contamination. Therefore these data do not represent a year-round average contamination.
- Users of nutrient data and contaminant data are not the same. Therefore, these data do not need to be reported in the same database.
- Even though in 'Total diet studies' (TDS) foods can be analysed both for contaminants and for nutrients, it is difficult to include the contaminant data into a food composition database because many foods are analysed as combined samples (i.e. different foods are put into one composite sample and analysed as such, e.g. composite sample of five vegetables). This means that contamination values are not always available for individual foods.

Reasons why chemical contaminants and antinutrients should be included:
Your answer should include any two of the following:

- Some user groups wish to combine intakes of nutrients, antinutrients and contaminants. They would gain from a compositional database reporting on all such components present in foods.
- When compositional data (nutrients, contaminants, etc.) are reported for the same foods, it should be possible to include data on nutrients, contaminants and antinutrients in one database;
- For food control and policy purposes, it is useful to have all data in one database.
- They are useful to give better nutritional advice, e.g. to pregnant women, by considering nutrients at the same time as contaminants.
- They are useful to investigate interactions between nutrients and contaminants.
- Analytical instruments for nutrient and contaminant analysis are often identical or similar.

IVa.Q14 Bioactive non-nutrient components are rarely included in the main body of user tables and databases. If data on bioactive non-nutrient components are disseminated, they are either listed in annexes of user tables or databases or published through special databases. Select the main reason why data on bioactive food components are not included in the main body of user tables and databases. *(1 point)*

Answer (see Greenfield & Southgate, 2003, pp. 61, 144-145):

	Main reason for disseminating data on bioactive food components in annexes of user databases or tables or through special databases
	Analytical methods are not available.
x	A full dataset of bioactive components are not available for most foods.
	Bioactive components are not thought to protect against cardiovascular disease and cancer, and are therefore not included in food composition tables and databases.
	The space in user databases is limited.

IVa.Q15 Match the following bioactive food components to the groups where they belong. *(2 points: ½ point for each correct response)*

Bioactive food component groups:

1. Flavonoids
2. Isoflavones
3. Coumestan
4. Lignans

Answer (see Greenfield & Southgate, 2003, pp. 144-145):

	Bioactive food components
3	Coumestrol
1	Quercetin
4	Isolariciresinol
2	Genistein

IVa.Q16 A lower Glycemic Index (GI) is thought to reduce the risk of cancer and diabetes. It has been proposed that GI values be included in food composition databases. Indicate the possible reasons why GI values are not regularly part of food composition databases. Select True or False. *(2 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 117):

True	False	Reasons for non-inclusion of GI values in food composition databases
x		GI values are affected by cooking and processing.
x		GI measurements have a high intra-individual variation, leading to greater uncertainty about GI values.
	x	GI measurements using glucose or white bread as a standard provide similar values.
	x	GI values are available for most foods.

SAMPLE ANSWERS TO THE EXERCISES

IVa.E1 In a country there are problems of micronutrient deficiencies (anaemia, vitamin A, goitre and osteoporosis) and an increasing problem of cancer and cardiovascular disease related to high intakes of fat, sugar and cholesterol. The labelling law requires that the content of the following nutrients should appear on the standard label: energy, carbohydrates, added sugar, protein, fat, dietary fibre, *trans* fatty acids (and nutrients for which a content claim is made must also be included – but this is beyond the scope of this question). Recommended daily intakes (RDI) exist for energy, fat, protein, iron, calcium, vitamins B_1, B_2, C, A, E and folate. Indicate, for each component, the reason(s) for their inclusion in the comprehensive user food composition databases. *(6 points: ½ point if all answers are correct per component)*

Answer (see Greenfield & Southgate, 2003, pp. 47-49):

Component	RDI exists	Labelling	Public health concern
Energy	x	x	x
Water			
Available carbohydrates by difference (or another carbohydrate expression)		x	
Sugars, total		(x [1])	x
Added sugar		x	x
Saturated fatty acids		(x [1])	x
Trans fatty acids		x	x
Iron	x	(x [1])	x
Calcium	x	(x [1])	x
Iodine		(x [1])	x
Vitamin C	x	(x [1])	(x – increases iron absorption)
Vitamin A	x	(x [1])	x

x [1]= if a content claim is made, but this is beyond the scope of the question. Answers in brackets do not count to obtain the full number of points.

IVa.E2 In the FAO/WHO report *Diet, Nutrition and the Prevention of Chronic Diseases*[10], the following ranges of population nutrient intake goals are recommended. State the nutrients, for which governments cannot assess if their population follows these goals when using the USDA, Danish or FAO tables for Africa. *(5.5 points: ½ point for each nutrient not present)*

Dietary factor	Goal (% of total energy, unless otherwise stated)
Total fat	15 – 30%
Saturated fatty acids	< 10%
Polyunsaturated fatty acids (PUFAs)	6 - 10%
n-6 Polyunsaturated fatty acids (PUFAs)	5 - 8%
n-3 Polyunsaturated fatty acids (PUFAs)	1 - 2%
Trans fatty acids	< 1%
Monounsaturated fatty acids (MUFAs)	By difference [a]
Total carbohydrate	55 – 75%[b]
Free sugars	< 10%
Protein	10 – 15%[d]
Cholesterol	< 300 mg per day
Sodium chloride (sodium)	< 5 g per day (< 2 g per day)
Fruit and vegetables	≥ 400 g per day
Total dietary fibre (Non-starch polysaccharides – NSP)	> 25 g (> 20 g)

[a] This is calculated as: total fat - (saturated fatty acids + polyunsaturated fatty acids + trans fatty acids).
[b] The percentage of total energy available after taking into account that which is consumed as protein and fat: hence the wide range.
[c] The term 'free sugars' refers to all monosaccharides and disaccharides added to food by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and fruit juices.
[d] The suggested range should be seen in the light of the Joint WHO/FAO/UNU Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition, held in Geneva on 9-16 April 2002 (*2*).
[e] Salt should be iodized appropriately (*6*). The need to adjust salt iodization, depending on observed sodium intake and surveillance of iodine status of the population, should be recognized.

Note:
- The USDA table is available at http://www.ars.usda.gov/Services/docs.htm?docid=8964, the nutrient definition file at http://www.nal.usda.gov/fnic/foodcomp/Data/SR20/asc/NUTR_DEF.txt and documentation pp. 7 ff. and http://www.nal.usda.gov/fnic/foodcomp/Data/SR20/SR20_doc.pdf
- The Danish table is available at http://www.foodcomp.dk/v7/fcdb_search.asp
- The FAO table is available at the INFOODS website http://www.fao.org/docrep/003/X6877E/X6877E00.htm

Answer:

Not in USDA SR20
- Free sugars

Not in Danish table

Not in FAO table for Africa
- Saturated fatty acids
- Monounsaturated fatty acids

[10] WHO Technical Report, Series 916 of 2003, available at: http://www.fao.org/WAIRDOCS/WHO/AC911E/AC911E00.HTM

- Polyunsaturated fatty acids
- n-6 Polyunsaturated fatty acids
- n-3 Polyunsaturated fatty acids
- *Trans* fatty acids
- Free sugars
- Cholesterol
- Sodium
- Total dietary fibre/Non-starch polysaccharides

For your information:
Further explanations of the differences in units, definition and methods are provided in modules 4.b, 4.c and 4.d.

The FAO/WHO Expert consultation on Fats and Fatty Acids in Human Nutrition (FAO, 2009 in press), which was held in November 2008, indicate different recommendations for fat and fatty acids. For adults, the following intakes in percent of energy were recommended:
- Total fat: 20 – 35%
- Saturated fatty acids: < 10%
- MUFA: by difference
- PUFA: 6 – 11%
- n-6 PUFA: 2.5 – 9%
- n-3 PUFA: 0.5 – 2%
- *Trans* fatty acids: < 1%

GENERAL FEEDBACK USING SELF-RATING

34 – 51.5 points: You have understood and integrated the selection of components. Congratulations. You are well prepared to proceed to the next module and to apply the new knowledge.

23 – 33 points: You have understood and integrated most issues on the selection of components. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so in order to effectively apply the new knowledge.

12 – 22 points: You have understood and integrated a fair part of issues on the selection of components. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

0 – 11 points: It seems you have significant gaps in your understanding of issues on the selection of components. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

Module 4.b

COMPONENT NOMENCLATURE

LEARNING OBJECTIVES

By the end of this module the student will be able to:

- grasp the importance of unambiguous food component identification for sampling, analysis, compilation, and use;
- understand the impact of component nomenclature on nutrient values;
- understand the concept of INFOODS food component identifiers (known as tagnames) and other systems, and how they can be used in food composition tables and databases;
- apply INFOODS food component identifiers to different nutrient definitions.

REQUIRED READING

- **Charrondière, U.R**. 'Component nomenclature', available at: http://www.fao.org/infoods/presentations_en.stm

and if possible:

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use.* FAO. Rome. Chapters 7 (pp. 101–105 and 146-147[11]) and 9 (pp. 163-170 and 179-180) and p. 223. Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf
- **Klensin, J.C., Feskanich, D., Lin, V., Truswell, S.A. & Southgate, D.A.T**. 1989. *Identification of Food Components for INFOODS Data Interchange.* UNU, Tokyo. In PDF file: Introduction pp. 5-15 and pp. 72-90 to find tagnames. Available at: http://www.unu.edu/unupress/unupbooks/80734e/80734E00.htm and as PDF file at ftp://ftp.fao.org/es/esn/infoods/Klensinetal1989Identificationoffoodcomponents.pdf.
- **Schlotke, F., Becker, W., Ireland, J., Møller, A., Ovaskainen, M.L., Monspart, J. & Unwin, I.** 2000. Eurofoods recommendations for food composition database management and data interchange. Report No. EUR 19538. *Office for Official Publications of the European Communities, Luxembourg.* Component description appears on p. 40 (and as suggested additional reading: component names on pp. 60-74). Available at: ftp://ftp.fao.org/ag/agn/infoods/EurofoodsRecommendations.pdf

EXERCISE MATERIAL

- Set of updated tagnames, including 2003 update, are available at: http://www.fao.org/infoods/tagnames_en.stm
- EuroFIR Component Thesaurus version 1.1. Available at: http://www.eurofir.org/eurofir/EuroFIRThesauri.asp . And version 1.0 at: http://www.eurofir.org/eurofir/Downloads/Thesauri/EuroFIR%20Thesauri%202008.pdf and http://www.eurofir.org/xml/EuroFIR_Component_Thesaurus_version_1_0_num.txt
- Chemical Entities of Biological Interest (ChEBI). Available at http://www.ebi.ac.uk/chebi/
- IUPAC International Chemical Identifier (InChI™). Available at: http://www.iupac.org/inchi/ and http://wwmm.ch.cam.ac.uk/inchifaq/
- Chemical Abstracts Service (CAS). See http://www.cas.org/. To search CAS numbers, see http://chem.sis.nlm.nih.gov/chemidplus/and http://chembiofinder.cambridgesoft.com/chembiofinder/SimpleSearch.aspx

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts +++++

[11] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to the PDF file.

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1–4 hours
- Answering the questions: 1-4 hours
- Completing the exercises: 1-4 hours

SUGGESTED ADDITIONAL READING

- **Charrondiere, U.R. & Burlingame, B.** 2007. Identifying food components: INFOODS tagnames and other component identification systems. *Journal of Food Composition and Analysis*, volume 20. pp. 713–716. Available at: http://www.sciencedirect.com/science?_ob=PublicationURL&_cdi=6879&_pubType=J&_auth=y&_acct=C000055286&_version=1&_urlVersion=0&_userid=6718006&md5=db64841e2924096349fdfba1225cba8a&jchunk=20#20

Answers to the questions

IVb.Q1 Are the commonly-used component names (e.g. vitamin C, carbohydrates) sufficiently precise to identify components unambiguously? Select the correct answer. *(1 point)*

Answer (see Klensin *et al.*, 1989, PDF file p. 5):

☐ Yes, because all commonly-used component names are sufficiently clear to everyone.

☒ No, because some commonly-used component names might include different chemical components or different calculation methods.

IVb.Q2 There are different systems to identify components:

1. Chemical Entities of Biological Interest (ChEBI);
2. Chemical Abstracts Service (CAS) Registry System;
3. IUPAC International Chemical Identifier (InChI™);
4. EUROFOODS/COST 99;
5. EuroFIR;
6. INFOODS Food Component Identifiers, also known as tagnames.

ChEBI and CAS use numbers, InChI an abbreviated chemical structure and EUROFOODS/COST 99, EuroFIR and INFOODS use abbreviated component names. The first three systems include only discrete chemicals but exclude sums of components. For food composition tables and databases, can ChEBI, CAS or InChI be used as the only component identification systems? Select the correct answer. *(1 point)*

Answer:

☐ Yes because all food components are chemicals.

☒ No, because in addition to specific chemical compounds, the components in food composition databases include sums of components (e.g. carbohydrates, saturated fatty acids), mixtures (e.g. dietary fibre) and nutritional activities (e.g. energy, vitamin A).

Optional question for those with advanced knowledge or who have participated in a food composition course

IVb.Q3 The EUROFOODS/COST 99 and the EuroFIR component identifiers are based on those of INFOODS. However, there are some fundamental differences concerning analytical methods between INFOODS and EuroFIR component identifiers. For one tagname, are there several EuroFIR components or vice versa? Select the correct answer. (1 point)

Answer (see Klensin *et al.*, 1989, pp. 5-15 and EuroFIR components version 1.1):

☒ For one EuroFIR component, several tagnames exist if the different methods generate significantly different values.

☐ For one tagname, several EuroFIR exist if the different methods generate significantly different values.

IVb.Q4 Describe the INFOODS food components, also known as tagnames. Indicate the correct responses from the following statements. Select True or False. *(4 points: ½ point for each correct response)*

Answer (see Klensin *et al.*, 1989, pp. 5-15):

True	False	Statements about tagnames
	x	1. Tagnames are food identifiers.
x		2. Tagnames are abbreviated food component identifiers that make the unambiguous identification of all food components possible, to the extent the analysis allows it.
x		3. Component values with the same tagname are comparable, whereas those with different tagnames are not.
	x	4. Tagnames with a dash '-' at the end identify nutrients for which there is no official analytical method.
	x	5. Food components for which different analytical methods generate significantly different results always have the same tagname.
x		6. Tagnames do not use symbols such as ':' because of potential problems in electronic data interchange.
x		7. New tagnames should be added when, for example, advances in analytical methods allow the determination of new components, or when the component is newly used in food composition tables or databases.
x		8. Tagnames are supplemented by 'keywords', which, for example, include additional information on calculation.

IVb.Q5 In the EuroFIR component naming system, information on methods and data expression are reported separately'. From the previous question (IV.Q4) select the two statements that do not therefore apply to the EuroFIR component naming system. *(1 point)*

Answer (see Klensin *et al.*, 1989, pp. 5-15 and EuroFIR components version 1.1):

The second and third statements do not apply to EuroFIR components:

- 2. Tagnames are abbreviated food component identifiers that make the unambiguous identification of all food components possible, to the extent the analysis allows it
- 3. Component values with the same tagname are comparable, whereas those with different tagnames are not comparable.

For your information:
Unlike INFOODS tagnames, the EuroFIR component thesaurus only identifies the component names without giving information on comparability of values owing to different methods and their performance (see modules 4.d and 6) or different expressions. As this information is important for users and compilers, the EuroFIR system will provide information on comparability at another stage.

It should be noted, however, that the EuroFIR component thesaurus includes three components for fibre, determined by different methods (NSP, FIBT, FIBC) and three for carbohydrates (CHOT, CHO, CHOU).

IVb.Q6 Units (e.g. grams) quantify the amount of a component (in the numerator), while the denominator (e.g. per 100 g edible food) indicates in which food quantity the components can be found (in the denominator). Match the following units and denominator to the corresponding statement: *(5 points: ½ point for each correct response)*

Units and denominator:
1. g
2. mcg
3. kJ
4. IU (international units)
5. per 100 mL
6. per kg
7. per g nitrogen
8. per 100 g dry matter
9. per 100 g total food (as purchased)
10. per 100 g edible portion

Answer (see Greenfield and Southgate, 2003, pp. 163, 165):

Statements	
Preferred unit for energy (according to SI)	3
Obsolete unit for vitamin A	4
Usual unit for macronutrients	1
Usual unit for folate and vitamin A	2
Usual denominator in food composition tables and databases	10
Denominator used in scientific articles to express nutrient values independent of water content	8
Denominator often used for contaminants	6
Denominator including inedible part	9
Derived denominator for amino acids	7
Denominator sometimes used for beverages	5

IVb.Q7 An update of INFOODS tagnames was undertaken in 2003. At that time, it was decided, among other things, to remove the default unit and denominator from tagnames because of the large number of combinations of units and denominators in use. Select the correct answer.
(1 point)

Answer (see Klensin *et al.*, 1989, pp. 5-15, tagname report of 2003):

☒ Since 2003, units and denominators are expected to be provided in addition to tagnames because they determine the nutrient value.

☐ The nutrient values of tagnames assigned after 2003 may be compared without additional information.

IVb.Q8 Select from the following components those for which several tagnames exist. (Take note that the concept of derived tagnames has been eliminated since 2003.) *(10 points: ½ point for each correct response)*

Answer (see Klensin *et al.*, 1989, pp. 15-90):

Common component names	Several tagnames exist
Energy	x
Water	
Carbohydrates	x
Sugars, total	x
Fibre	x
Protein	x
Fat	x
Fatty acid 18:1 cis n-9	
Calcium	
Potassium	
Folate	x
Thiamin	x (THIA, THIAHCL)
Riboflavin	
Niacin	x
Vitamin C	x
Vitamin A	x
β-carotene equivalent	
Vitamin D	x
Vitamin E	x
Vitamin K	

For your information:
For some tagnames it is also important to know the conversion factors and components used to constitute the equivalent. Further information in this regard is provided in module 4.c.

Common component names	Keywords needed for the same tagname to distinguish differences in values
Energy	conversion factors and contributing components
Water	
Carbohydrates	
Sugars, total	
Fibre	
Protein	conversion factors
Fat	conversion factors in FATNLEA
Fatty acid 18:1 cis n-9	
Calcium	
Potassium	
Folate	conversion factors in DFE
Thiamin	
Riboflavin	
Niacin	conversion factors in NIAEQ
Vitamin C	
Vitamin A	conversion factors and contributing components
β-carotene equivalent	conversion factors and contributing components
Vitamin D	conversion factors and contributing components
Vitamin E	conversion factors and contributing components
Vitamin K	

IVb.Q9 If several tagnames or keywords (describing different definitions) are found for the same nutrient, what should the user check before being able to use the component values? *(1 point)*

Answer (see Klensin *et al*., 1989, pp. 5-15):

Components represented by different tagnames cannot be compared or combined directly because the different analytical methods for these components yield significantly different results. Therefore, the user should always check the definition and calculation methods for those components which can have different tagnames and keywords so that only those values are combined which have the same definition and keywords.

IVb.Q10 Complete the following tables per nutrient:

1. Match the definitions with the corresponding tagname(s);
2. Match the statements of recommended use in food composition tables and databases with the tagnames;
3. Rank the nutrient values of the different tagnames.

Answer (see Klensin *et al*., 1989, pp. 16-90 and INFOODS tagnames at http://www.fao.org/infoods/tagnames_en.stm):

(a) Fat *(4 points: ½ point for each correct response)*

Definitions
1. Fat, total. Derived by analysis using continuous extraction (Soxhlet method). The nutrient values are lower for cereals but comparable for other food groups.
2. Fat, total. Sum of triglycerides, phospholipids, sterols and related compounds. The analytical method is a mixed solvent extraction.
3. Total fat by NLEA definition (triglyceride equivalents of fatty acids). This is used for labelling in the United States of America.

Recommended use in food composition tables and databases
1. Not recommended
2. Recommended
3. Acceptable except for cereals and cereal products

Ranking of nutrient values for cereals
1. Tagname provides highest value among all definitions
2. Tagname provides second highest value among all definitions
3. Tagname provides lowest value among all definitions

Tagname	Match with definition	Recommended use in food composition tables and databases	Ranking of nutrient values
FAT	2	2	1
FATNLEA	3	-----------------	2
FATCE	1	3	3

For your information:
The Soxhlet method is used in many countries. Care should be taken to avoid determining fat values for cereals with this method unless there are other extractions performed, e.g. acid hydrolysis. For other food groups, the fat values are comparable.

(b) Carbohydrates *(4.5 points: ½ point for each correct response)*

Definitions
1. Total carbohydrates. This value is the sum of analytical values of sugars, starch, oligosaccharides and dietary fibre. The nutrient value should be similar to 'Total carbohydrates by difference'. However, nowadays, the concept of available carbohydrates is considered more appropriate and therefore total carbohydrates should be phased out.
2. Available carbohydrates by weight. This value is the sum of analytical values of sugars, starch and glycogen.
3. Available carbohydrates in monosaccharide equivalent. This value is the sum of analytical values of sugars, starch and glycogen. The nutrient value is higher than 'Available carbohydrates by weight' because it includes the residual water from the hydrolysis around each monosaccharide. This expression is currently not commonly used in food composition tables and databases(but in the British table).
4. Total carbohydrates by difference. This value is calculated as follows: 100 g minus total grams of water, protein, fat, alcohol and ash. The nutrient value is higher than 'Available carbohydrates by difference' by the amount of the fibre value and includes the analytical errors of all contributing nutrients. It is therefore not recommended for use as the only expression for carbohydrates in food composition tables and databases.
5. Available carbohydrates by difference. This value is calculated as follows: 100 g minus total grams of water, protein, fat, alcohol, ash and dietary fibre; or total carbohydrates minus dietary fibre. The nutrient value is similar to 'Available carbohydrates by weight', but includes the analytical errors of all contributing nutrients. It should therefore be phased out. However, this expression is acceptable for countries unable to generate analytical values for carbohydrates.

Recommended use in food composition tables and databases
1. Most recommended expression (select only one tagname)
2. Least recommended (select only one tagname)

Ranking of nutrient values
1. Tagname provides highest value among all definitions (select only one tagname)
2. Tagname provides lowest value among all definitions (select only one tagname)

Tagname	Match with definition	Recommended use in food composition tables and databases	Ranking of nutrient values
CHOAVL	2	1	2
CHOAVLM	3		
CHOAVLDF	5		(2)
CHOCDF	4	2	1
CHOCSM	1		(1)

For your information:
The main difference in carbohydrate relates to:

- whether or not fibre is included: Total carbohydrates include fibre whereas available carbohydrates exclude fibre.
- if expressed in anhydrous form (without residual water) or monosaccharide equivalents (with residual water): The available carbohydrates in monosaccharide equivalents provide higher values than available carbohydrates because of the residual water from the hydrolysis around each monosaccharide. It is recommended that available carbohydrates by weight (CHOAVL) be used because they represent the carbohydrates available to the human body and are normally generated through analytical work.
- if analysed or calculated by difference: Carbohydrate expressions by difference are not recommended because analytical errors of the contributing components have an influence on the carbohydrate value.

Available carbohydrates by difference are, however, more acceptable than total carbohydrates by difference because at least 'Available carbohydrates by difference' represents only the carbohydrates available to the human body. 'Total carbohydrates by difference' are not recommended and should be phased out because they include fibre and analytical errors of the contributing components. 'Total carbohydrates by summation' (CHOCSM) expression is more acceptable because it is also an analytical value. However, available carbohydrates are the preferred expression. Dietary fibre is not digested in the human small intestine and provides less energy to the human body compared with available carbohydrates (8 vs. 17 kJ or 2 vs. 4 kcal per g).

Some databases contain several expressions for carbohydrates because of different user or regulatory requirements.

Both expressions of total carbohydrates should provide similar values. The same is true for the two expressions of available carbohydrates – by difference and by weight. The points are achieved if either total carbohydrates expression is indicated by 1, and if available carbohydrates – by difference or by weight – are indicated by 2.

(c) Fibre *(5.5 points: ½ point for each correct response)*

Note: It might be helpful to consult figure in FAO (2003) p. 26 in PDF file at ftp://ftp.fao.org/docrep/fao/006/y5022e/y5022e00.pdf .

Definitions

1. Total dietary fibre by AOAC Prosky method, which is the recommended method. It is a mixture of non-starch polysaccharides, lignin, resistant starch and resistant oligosaccharides.
2. Non-starch polysaccharide, also called Englyst fibre. This includes non-starch polysaccharides but excludes lignin, resistant starch and resistant oligosaccharides.
3. Southgate fibre: mixture of non-starch polysaccharides, lignin and some resistant starch. It is an approximation of FIBTG and should have similar values to FIBTG for foods without resistant starch.
4. Fibre, acid detergent method, Clancy modification. This includes lignin, cellulose, some hemicellulose and some pectin.
5. Fibre; determined by neutral detergent method. This includes lignin, cellulose, and insoluble hemicellulose.
6. Crude fibre. Its use is discouraged for human nutrition because it captures only fractions of lignin, cellulose and hemicellulose.
7. Fibre; unknown or mixed methods.

Recommended use in food composition tables and databases

1. Most recommended because it captures most completely the components with dietary fibre functions (select only one tagname)
2. Least recommended because it is obsolete in human nutrition (select only one tagname)

Ranking of nutrient values

1. Tagname generally provides highest value among all definitions (select only one tagname)
2. Tagname generally provides lowest value among all definitions (select only one tagname)

Tagname	Match with definition	Recommended use in food composition tables and databases	Ranking of nutrient values in fibre rich foods
FIB-	7		
FIBTS	3		(1)
FIBAD	4		
FIBTG	1	1	1
FIBC	6	2	2
FIBND	5		
PSACNS/NSP	2		

For your information:
There is no international agreement on the preferred dietary fibre definition but FIBTG represents the method that includes fibre fractions in the most complete manner. Other analytical methods are being developed to capture resistant starch even more comprehensively.

(d) Vitamin C *(3 points: ½ point for each correct response)*

Definitions

1. Vitamin C: sum of L-ascorbic acid plus L-dehydroascorbic acid. They are normally analysed by HPLC.
2. L-ascorbic acid: Values are comparable with vitamin C in unprocessed foods. Titrimetry can only analyse L-ascorbic acid.

Recommended use in foods composition tables and databases

1. Recommended
2. Acceptable for fresh fruit and vegetables

Ranking of nutrient values

1. Tagname provides highest value among all definitions;
2. Tagname provides lowest value among all definitions.

Tagname	Match with definition	Recommended use in food composition tables and databases	Ranking of nutrient values
VITC	1	1	1
ASCL	2	2	2

(e) Folate *(6.5 points: ½ point for each correct response)*

Definitions

1. Folic acid: synthetic folic acid used in fortification
2. Total folate: food folate + folic acid. It includes both conjugated and free folate and is determined by microbiological assay.
3. Food folate: naturally occurring food folates, analysed by microbiological assay.
4. Dietary folate equivalent (DFE): food folate (pteroylpolyglutamates) + 1.7 x synthetic folic acid (pteroylmonoglutamic acid).
5. Sum of folate vitamers determined by HPLC. It includes mostly tetrahydrofolate, 5-methyltetrahydrofolate, 5-formyltetrahydrofolate, 10-formylfolic acid, 10-formyldihydrofolate and folic acid.

Ranking of nutrient values

1. Tagname provides highest value among all definitions. (There are three tagnames with equal amounts; indicate 1 for all three.)
2. Tagname provides second highest value among all definitions
3. Tagname provides lowest value among all definitions

Tagname	Match with definition	Ranking of nutrient values in unfortified foods
FOL	2	1
FOLSUM	5	2
FOLAC	1	3
FOLDFE	4	1
FOLFD	3	1

Ranking of nutrient values
1. Tagname provides highest value among all definitions
2. Tagname provides second highest value among all definitions
3. Tagname provides third highest value among all definitions
4. Tagname provides forth highest value among all definitions
5. Tagname provides lowest value among all definitions

Tagname	Ranking of nutrient values in fortified foods when the amount of the fortificant exceeds that of natural folate
FOL	2
FOLSUM	3
FOLAC	4
FOLDFE	1
FOLFD	5

For your information:
Some food composition tables and databases and other sources erroneously use the term 'folic acid' when what is meant is 'folate'. This should be avoided as it may create confusion. Folic acid is not found naturally in foods but is used for fortification.

In most cases, the microbiological method yields significantly higher values compared with HPLC. The latter method is being further developed; but for now the microbiological method is the preferred method. However, an increasing number of food composition tables and databases list folate values determined by HPLC. As HPLC generate lower values, the nutrient intake estimations in such cases are lower, calling for more and higher folate fortification.
In unfortified foods, FOL, FOLDFE and FOLFD all have the same amount of folate because folic acid is zero and therefore the natural occurring folate is identical. FOLSUM is lower as not all natural occurring folate is captured, and FOLAC is lowest value as it is zero.

In unfortified foods, FOL, FOLDFE and FOLFD all have the same amount of folate because folic acid is zero and therefore the natural occurring folate is identical. FOLSUM is lower as not all natural occurring folate is captured, and FOLAC is lowest value as it is zero.

In fortified foods, when the amount of folic acids is greater than the naturally occurring folate, FOLDFE generates the highest value as the folic acid amount is multiplied by 1.7. This is followed by FOL (as it is the sum of folate and folic acid), then by FOLSUM (because it includes natural folate and folic acid but at a lower value than FOL), and then by FOLAC (as the text specifies that it is higher than the natural folate). FOLFD is lowest as it includes only the natural folate in food.

(f) Vitamin A *(2.5 points: ½ point for each correct response)*

Definitions
1. Total vitamin A activity expressed in mcg retinol equivalent (RE) = mcg retinol + 1/6 mcg β-carotene + 1/12 mcg other provitamin A carotenoids (or RE =mcg retinol + 1/6 mcg β-carotene equivalent where β-carotene equivalents = 1 β-carotene + 0.5 α-carotene + 0.5 β-cryptoxanthin)
2. Total vitamin A activity expressed in mcg in retinol activity equivalent (RAE) is used e.g. in the United States Department of Agriculture (USDA) database = mcg retinol + 1/12 mcg β-carotene + 1/24 mcg other provitamin A carotenoids (or RE =mcg retinol + 1/12 mcg β-carotene equivalent CARTBEQ where β-carotene equivalents = 1 β-carotene + 0.5 α-carotene + 0.5 β-cryptoxanthin)
3. Vitamin A; determined by bioassay

Ranking of nutrient values
1. Tagname provides highest value among all definitions
2. Tagname provides lowest value among all definitions

Tagname	Match with definition	Recommended use in food composition tables and databases	Order of nutrient values
VITAA	3	--------------	------------
VITA	1	x	1
VITA_RAE	2	x	2

For your information:
In the United Kingdom, for retinol 'All-*trans* retinol equivalent' in mcg is used = mcg all-*trans* retinol + 0.75 mcg 13-*cis* retinol + 0.90 mcg retinaldehyde. To calculate vitamin A, the carotene contribution is added (1/6 mcg β-carotene + 1/12 mcg other provitamin A carotenoids).

Recent research indicates that vitamin A calculated as RAE is more appropriate because the conversion from carotenes into vitamin A is not as effective as originally thought. Many factors affect bioavailability and some scientists feel that a range of factors should be applied to each carotene, depending on the food matrix. It might be useful to hold an international expert consultation to reach an agreement on the most appropriate set of conversion factors for carotenes to account for their vitamin A activity (for uses in food composition, requirements, nutrient intake estimations and labelling).

(g) Vitamin E *(3 points: ½ point for each correct response)*

Definitions
1. α-tocopherol. In some databases, e.g. USDA SR16 and later releases, it is used to represent vitamin E.
2. Vitamin E: active tocopherols and tocotrienols, calculated as mg α-tocopherol equivalents (ATE or TE)[12]
   - = α-tocopherol + 0.4 β-tocopherol + 0.1 γ-tocopherol + 0.01 δ-tocopherol + 0.3 α-tocotrienol + 0.05 β-tocotrienol + 0.01 γ-tocotrienol (mostly used)
   - = α-tocopherol + 0.5 β-tocopherol + 0.1 γ-tocopherol + 0.3 α-tocotrienol
   - = α-tocopherol + 0.4 β-tocopherol + 0.1 γ-tocopherol + 0.01 δ-tocopherol
3. Vitamin E: determined by bioassay
4. Vitamin E: method unknown or variable; expressed as mg α-tocopherol equivalents

Ranking of nutrient values
1. Tagname provides highest value among all definitions
2. Tagname provides lowest value among all definitions

Tagname	Match with definition	Recommended use in food composition tables and databases	Order of nutrient values
VITE-	4		--------------
VITE	2	x	1
VITEA	3		-------------
TOCPHA	1	x	2

12 Information on calculations is to be included through the key words approach.

For your information:
According to the IOM report (2000)[13], even though tocopherols and tocotrienols are absorbed, they are not converted to α-tocopherol by humans and are poorly recognized by the α-tocopherol transfer protein (α-TTP) in the liver. Therefore, the report concludes that α-tocopherol is the only type of vitamin E that human blood can maintain and transfer to cells when needed because it seems to be the only vitamin E form with a good affinity for hepatic α-TTP.

It becomes necessary to reach international agreement about whether in the future only α-tocopherol or TE should be used to represent vitamin E in food composition tables and databases, for requirements, and in nutrient intake estimations and labelling.

(h) Vitamin D *(3 points: ½ point for each correct response)*

Definitions
1. Vitamin D (D_2 + D_3): sum of ergocalciferol (only occurring in plant foods) and cholecalciferol (occurring in animal foods). This definition is mostly used.
2. Vitamin D: determined by bioassay. The nutrient values are generally higher than the values determined chemically.
3. Vitamin D_3 + D_2 + 5 x 25-hydroxycholecalciferol (used in United Kingdom and Denmark): The nutrient values are higher than D_2+D_3 in food rich in 25-hydroxycholecalciferol, e.g. pork.
4. Cholecalciferol (Vitamin D_3). It is sometimes used to represent vitamin D in food composition tables and databases.

Ranking of nutrient values
1. Tagname provides highest value among all definitions

Tagname	Match with definition	Recommended use in food composition tables and databases	Order of nutrient values in pork	Order of nutrient values in plant foods
VITD	1	x		1
CHOCAL	4	(x)		
VITDA	2		---------------	---------------
VITDEQ	3	x	1	1

For your information:
The origin of the vitamin activity factor of 5 for 25-hydroxycholecalciferol is not documented. A factor of 1.7 may be more reasonable, but more research will be needed on this issue.

[13] **Institute of Medicine**, 2000. *Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium and Carotenoids.* National Academy of Sciences. Institute of Medicine. Food and Nutrition Board. *Available at http://fnic.nal.usda.gov/nal_display/index.php?info_center=4&tax_level=4&tax_subject=256&topic_id=1342&level3_id=5141&level4_id=10591*

IVb.Q11 Match the short vitamin names to the one or several components that are synonyms or have vitamin activity. *(6.5 points: ½ point for each correct response)*

Answer (see Klensin *et al.*, 1989, pp. 16-56):

Vitamin	Components/synonyms
A	Retinol, retinyl esters, retinaldehydes, carotenoids
B_1	Thiamin
B_2	Riboflavin
B_3	Niacin
B_5	Pantothenic acid
B_6	Pyridoxal
B_7, H	Biotin
B_9	Folates
B_{12}	Cobalamins
C	Ascorbic acid, dehydroascorbic acid
D	Calciferol
E	Tocotrienols, tocopherols
K	Quinones

IVb.Q12 Several attempts have been made to cluster components into groups. This was not done in INFOODS as it was deemed more appropriate to have component grouping external to the tagname and interchange system. Select the INCORRECT response as to why component grouping is difficult. *(1 point)*

Answer (see Klensin *et al.*, 1989, pp. 13-14):

	Incorrect reason for difficulty of component grouping
	Some components might belong to more than one group.
	No agreement has been reached on the composition of some component groups, e.g. proximates.
x	Component identification is not always possible.

SAMPLE ANSWERS TO THE EXERCISES

Optional question for those with advanced knowledge or who have participated in a food composition course

IVb.E1 For the following INFOODS tagnames find the corresponding component names or codes from EuroFIR, ChEBI and CAS. *(11 points: 1 point for each correct response per component).*

INFOODS tagnames are found on:

- Klensin, J.C., Feskanich, D., Lin, V., Truswell, S.A. and Southgate, D.A.T. 1989. Identification of Food Components for INFOODS Data Interchange. pp. 16-91 in PDF file at: ftp://ftp.fao.org/es/esn/infoods/Klensinetal1989Identificationoffoodcomponents.pdf
- Set of currently available tagnames, including updated ones, available at: http://www.fao.org/infoods/tagnames_en.stm

Other component identifiers may be found at:

- EuroFIR components thesaurus version 1.1 Available at: http://www.eurofir.org/eurofir/EuroFIRThesauri.asp . And version 1.0 at: http://www.eurofir.org/eurofir/Downloads/Thesauri/EuroFIR%20Thesauri%202008.pdf and http://www.eurofir.org/xml/EuroFIR_Component_Thesaurus_version_1_0_num.txt
- Chemical Entities of Biological Interest (ChEBI). Available at http://www.ebi.ac.uk/chebi/
- Chemical Abstracts Service (CAS). Available at http://www.cas.org/. To search CAS numbers, see http://chem.sis.nlm.nih.gov/chemidplus/ and http://chembiofinder.cambridgesoft.com/chembiofinder/SimpleSearch.aspx

Note: The purpose of this exercise is to demonstrate that ChEBI or CAS cannot be used exclusively as a component identifier system for food composition purposes because they do not include codes for those nutrients which are summations or equivalents or which are determined by different analytical methods or expressions. In addition, it helps users appreciate the differences in component naming between INFOODS and EuroFIR.

Answer:

Tagname	Component name	EuroFIR component	ChEBI code	CAS code
XN	Conversion factor to calculate total protein from nitrogen	-	-	-
ALA	Alanine. Includes only L-arginine	ALA	ChEBI:16977	56-41-7
SUGAR	Sugars, total	SUGAR	-	-
SUGARM	Sugars, total; expressed in monosaccharide equivalents	SUGAR	-	-
FAMS	Fatty acids, total monounsaturated	FAMS	-	-
F18D1TN9	Fatty acid trans 18:1 n-9; elaidic acid; octadecenoic acid	F18:1TN9	ChEBI:27997	112-79-8
F18D1CN9	Fatty acid 18:1 cis n-9; oleic acid	F18:1CN9	ChEBI:16196	112-80-1
FIBTG	Total dietary fibre by AOAC Prosky method	FIBT	-	-
PSACNS /NSP	Non-starch polysaccharide = Englyst fibre	NSP	-	-
CARTB	β-carotene	CARTB	ChEBI:17579	7235-40-7
VITD-	Vitamin D; method of determination unknown	-	-	-

For your information:

EuroFIR components are in most cases equal to INFOODS component identifiers. There are only some exceptions such as:

- fatty acids (EuroFIR uses a column while INFOODS uses 'D' instead);
- EuroFIR includes method information and expressions in the interchange format and thus excludes them from the component names. In contrast, INFOODS has different tagnames if significantly different values are generated by empirical methods (e.g. dietary fibre, folate) or expressions (e.g. carbohydrates);
- for unknown determination or mixed of methods INFOODS always uses a dash -; and
- INFOODS treats conversion factors as components.

IVb.E2 Determine the order in the following foods, from the highest to the lowest, of fat values using FAT, FATCE, FATNLEA. It may be useful to recheck the definitions of fat in Ivb.Q10 (a) fat. See example of Beef steak. *(3 points: 1 point for each correct response per component)*

Answer:

a) **Beef steak: FAT = FATCE > FATNLEA**
b) **Wheat:** FAT > FATNLEA > FATCE
c) **Trout**: FAT = FATCE > FATNLEA
d) **Olive oil**: FAT = FATCE > FATNLEA

For your information:
FAT includes triglycerides, phospholipids, sterols and related compounds. FATCE includes the same components but the value in cereals is lower owing to incomplete extraction requiring additional steps in preparation or a different method of analysis. FATNLEA is always lowest because it is the sum of fatty acids only.

IVb.E3 In the following foods, determine the order of the dietary fibre values, from the highest to the lowest, using FIBC, FIBTG, FIBTS, PSACNS/NSP and FIB-. *(3 points: 1 point for each correct response per component)*

Note: It would be helpful to look at the tables on pp. 14-15 of FAO (2003): *Food energy - methods of analysis and conversion factor*, available at ftp://ftp.fao.org/docrep/fao/006/y5022e/y5022e00.pdf.

Example: Brown bread: FIBTG > FIBTS (but similar to FIBTG)> PSACNS/NSP > FIBC

Answer (see Greenfield and Southgate, 2003, p. 103):

a) **Dates, dried** (no resistant starch, 2 g lignin): FIBTG = FIBTS > PSACNS/NSP > FIBC
b) **Mango** (no resistant starch, 0.3 g lignin): FIBTG =FIBTS = PSACNS/NSP > FIBC
c) **Spaghetti, boiled** (resistant starch, 0.1 g lignin): FIBTG >FIBTS > PSACNS/NSP > FIBC

For your information:
FIB- can have any value as it may represent FIBC, FIBTG, FIBTS, PSACNS/NSP or a mixture of them. FIBC always has the lowest value as all fibre components are incompletely determined, if at all. FIBTG should always have the highest value because all fibre fractions are measured in the most complete way. FIBTG and FIBTS should be similar if the food has little or no resistant starch. The difference between FIBTS and PSACNS/NSP is that the latter does not include lignin, resistant starch and resistant oligosaccharides.

This logic is not always reflected in the different food composition tables for reasons of sampling, analytical quality or due to borrowing and imputing values. For example, for raw spaghetti the United Kingdom table (McCance and Widdowson's, 6^{th} edition) states FIBTS as 5.1 g and PSACNS/NSP as 2.9 g, and the United States Department of Agriculture (USDA) table SR20 FIBTG as 3.2 g. For boiled spaghetti, in the United Kingdom table FIBTS is 1.8 g and PSACNS/NSP is 1.2 g, while in the USDA database SR20 FIBTG is 1.8 g.

IVb.E4 Indicate the corresponding tagname for the following nutrients appearing in the British food composition database McCance and Widdowson's *The Composition of Foods* integrated dataset (CoF IDS), available at: http://www.food.gov.uk/science/dietarysurveys/dietsurveys/. Read the sections *Details on Nutrient Data* (pp.4-7) and *Nutrient Definitions and Expressions* (pp.17-27) in the documentation (available at http://www.food.gov.uk/multimedia/pdfs/cofuserdoc.pdf). (*15 points: 1 point for each correct response per component*)

Answer:

Nutrient in CoF IDS	Corresponding tagname
Protein	PRONT/PROT (and PROCNP)
Fat	Not possible to indicate as analytical method is missing. Not possible to decide if FAT or FATCE
Carbohydrates	CHOAVLM in most cases and few in CHOCDF
Water	WATER
Energy	ENERC
Dietary fibre	FIBTG and PSACNS/NSP
Cholesterol	CHOL-
Retinol	RETOLEQ
Vitamin A	VITA
Vitamin D	VITDEQ
Vitamin E	VITE
Vitamin C	VITC for newer values and ASCL for older ones
Folate	FOL
Niacin	NIA, NIATRP and NIAEQ
Calcium	CA

GENERAL FEEDBACK USING SELF-SCORING

***71 – 96.5 points*:** You have understood and integrated the issues on component nomenclature. Congratulations. You are well prepared to proceed to the next module. You will be able to use component nomenclature correctly.

***47 – 70 points*:** You have understood and integrated most of the issues on component nomenclature. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so before proceeding to the next module. You will probably be able to use component nomenclature correctly.

***23 – 46 points*:** You have understood and integrated a fair part of the issues on component nomenclature. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so before proceeding to the next module and being able to apply component nomenclature in your work.

***0 – 22 points*:** You appear to have significant gaps in your understanding of issues component nomenclature. You should read the sections again and improve your knowledge of these topics. This is highly recommended that you do so in order to effectively apply the new knowledge.

Module 4.c

COMPONENT CONVENTIONS AND EXPRESSIONS

LEARNING OBJECTIVES

- by the end of this module the student will be able to:
- understand the concepts of unit and denominator and their importance for data definition and values;
- comprehend principles of nutrient calculation using conversion factors and/or aggregations of components;
- grasp the implications of different expressions and calculations of nutrient values on database management and data use and apply them when selecting appropriate data;
- recalculate nutrient values using different units and denominators;
- determine nutrient values, which by definition are calculated values.

REQUIRED READING

- **Charrondière, U.R**. 'Component conventions and expressions' available at: http://www.fao.org/infoods/presentations_en.stm

and if possible:

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use.* FAO. Rome. Chapters 7 (pp. 101-104, 146-147)[14] , 9 (pp. 163-170) and 11 (pp. 179-181) and appendix 5 (p. 223). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf
- **FAO.** 2003. *Food energy - methods of analysis and conversion factors.* PDF version. FAO, Rome. pp. 18-35. Available at: ftp://ftp.fao.org/docrep/fao/006/y5022e/y5022e00.pdf
- **Codex Alimentarius**. 2001. *Food Labelling – Complete Texts (revised).* FAO, Rome. pp. 32-34. Available at: ftp://ftp.fao.org/docrep/fao/005/y2770E/y2770E00.pdf

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts +++++

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1–3 hours
- Answering the questions: 1–2 hours
- Completing the exercises: 1–2 hours

[14] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to the PDF file.

Answers to the questions

IVc.Q1 Each compositional value is defined by a unit (how much of the component) and a denominator (in how much of something, e.g. food). Give three examples of each, as used in food composition. *(3 points: ½ point for each correct response*)

Answer (see Greenfield & Southgate, 2003, pp. 163, 165):

Your answer should include any three of the following units and denominators:

Unit	Denominator
g	per 100 g edible portion
mg	per 100 mL
mcg	per g nitrogen
kJ	per 100 g protein
kcal	per 100 g total fatty acids
IU (international units)	per 100 g dry matter (DM)
	per 100 g total food (as purchased)
	per kg

For your information:
Careful attention should be paid to units and denominators when interchanging or transferring nutrient values from one source to another (e.g. from laboratory reports, articles or other food composition databases to one's own food composition database).

IVc.Q2 Most published food composition databases express compositional data per 100 g edible portion. Other sources may use other denominators and/or a mixture of denominators. Select the statement(s) describing the implication(s) when a mix of denominators is used in a food composition table or database. Select True or False. *(3.5 points: ½ point for each correct response)*

Answer (see also Greenfield & Southgate, 2003, pp. 163, 166, 179-181):

True	False	Implication(s) for the user when a mix of denominators is used
x		The user needs the units and denominators to evaluate the nutrient intakes. A mix of denominators might be confusing.
	x	All users know the difference between per 100 g of food as purchased (i.e. including inedible part) and per 100 g edible portion, and are able to select the appropriate food for their purposes.
x		Several food entries in the food composition table or database with different denominators may facilitate the calculation of nutrient intake estimations for the user (i.e. it is easy to match beverages reported in mL to nutrient values in mL).
x		Some users might transfer all nutrient values to a database or worksheet and attribute the same denominator, without noticing that certain foods have different denominators.
	x	Users and compilers would always notice that data expressed per 100 g dry matter have higher values compared to per 100 g edible portion, and would convert the values accordingly when introducing them into a database using per 100 g edible portion.
x		When entering nutrient values from different sources, the compiler may not always pay attention to the denominator and thereby introduce errors into one's own database.
	x	The nutrient values of all beverages are the same, whether expressed in 100 g or 100 mL.

For your information:
Some journals publish nutrient values per 100 g dry matter and these values might be accidentally transferred to 'per 100 g edible food'; or because of a missing water value, the user of these values may

have to take another (most probably different) water value from a similar food and might therefore introduce errors. It would be useful if all journals publishing food composition data, on a fresh or dry matter basis, would provide a water value. Because water loss (or gain, in some cases) is a routine and serious problem in sample handling, a water value should always be determined. All nutrient values are affected by even small changes in water.

IVc.Q3 Conversion factors are used to convert a quantity expressed in one set of units to another set of units, or to account for different nutrient activities. Which nutrients are always calculated using conversion factors? Select True or False. *(2.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 167-170, 179-181):

True	False	Nutrients always calculated using conversion factors in food composition databases
x		Energy, protein (based on total nitrogen)
	x	Energy, protein, total carbohydrates by difference
	x	Vitamins D, E, A
	x	Vitamin A (as RE), vitamin E (as TE), β-carotene equivalent, dietary folate equivalent (DFE), vitamin D (as in British table), vitamin C
x		Vitamin A (as RE), vitamin E (as TE), β-carotene equivalent, dietary folate equivalent (DFE), vitamin D (as in British table)

For your information:
Vitamin D is often expressed only as vitamin D_3 or as sum of D_2 and D_3. The British tables express vitamin D as $D_3 + D_2 + 5 \times$ 25-hydroxycholecalciferol. Vitamin E is now frequently expressed only as α-tocopherol, instead of as α-tocopherol equivalent . Therefore, conversion factors are not always used for these vitamins, nor for protein, if it is calculated based on the sum of amino acids, as in the case of infant formulae. Vitamin C and total carbohydrates by difference are calculated without the use of conversion factors.

IVc.Q4 The nitrogen-to-protein conversion factor is used to convert the total nitrogen value to the protein value. The usual factor is 6.25, which assumes that proteins contain 16% nitrogen. Because most plant proteins contain larger amounts of nitrogen, and animal protein contains smaller amounts, the nitrogen-to-protein conversion factors are lower in plants and higher in animal foods (see table 7.3 of Greenfield and Southgate (2003) at p. 104). These conversion factors are also known as Jones factors which were adopted by FAO/ WHO (1973) for protein requirement calculation. What influence do these factors have on compositional data? Select True or False. *(3.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 101-103):

True	False	Influence of different nitrogen-to-protein conversion factors
	x	In recent years, lower nitrogen-to-protein conversion factors have been proposed but have not yet been widely adopted or used. If they were to be applied, all protein values would be higher.
x		Many labelling regulations use only the general nitrogen-to-protein conversion factor of 6.25. This means that the protein value on a label of milk is lower than the protein value of the same milk in the food composition table using Jones factors.
	x	All food composition databases use the same Jones factors, as published by FAO/WHO (1973).
x		Because nitrogen-to-protein conversion factors determine the protein content of foods, they should be stated in the introduction to a food composition table and form part of the documentation of a food composition database.
x		The nitrogen-to-protein conversion factors influence the energy value of foods.
x		When borrowing protein values from other sources, applicability of the nitrogen-to-protein conversion factors should be verified.
x		Nitrogen-to-protein conversion factors have tagnames and can be included in the database for each

		food. This is useful when factors change over time.

IVc.Q5 Food composition tables and databases use the 'metabolizable energy' system that is based on the Atwater energy conversion factors. 'Gross energy' and 'net metabolizable energy' are generally not used in food composition tables and databases. In the table below, match the definitions to the energy conversion systems and then rank the energy values from 1 (highest) to 7 (lowest) when used for a diet rich in cereals. *(7 points: ½ point for each correct response)*

Note: See also FAO (2003), sections 3.4 and 3.5 (PDF version available at: ftp://ftp.fao.org/docrep/fao/006/y5022e/y5022e00.pdf) and Codex Alimentarius (2001), section 3.3.1 (available at: ftp://ftp.fao.org/docrep/fao/005/y2770E/y2770E00.pdf)

Definitions
1. The system is derived from the specific Atwater factors applied to a normal American diet, and is used in most food composition tables and databases.
2. The factors are determined with the ballistic bomb calorimeter, and should be corrected for the heat generated from the oxidation of nitrogen and sulphur in the food. The energy values are therefore higher than for metabolizable energy. These factors are not commonly used in food composition tables and databases.
3. The food energy available for body functions that requires adenosine triphosphate (*ATP*). In most cases, the energy value is lower than the metabolizable energy value of the same food. These factors are not used in food composition tables and databases.
4. Specific factors are used if available, and general factors are used for the remaining foods. The United States Department of Agriculture (USDA) database uses this system and includes total carbohydrate by difference.
5. The biological availability and variability of the compounds in the different foods are taken into account. As a result, energy conversion factors differ between foods. However, these factors are available for a small number of foods only.
6. The system uses the general Atwater factors and adds a factor for organic acids.
7. The energy derived from the specific Atwater factors applied to a normal American diet with an energy value for dietary fibre. These factors are those most recommended for use in food composition tables and databases.

Answer (see Greenfield & Southgate, 2003, pp.146-147and 179-180; Codex Alimentarius (2001) section 3.3.1; and FAO (2003) sections 3.4 and 3.5.):

Energy conversion system	Energy conversion factors in kJ/g (kcal/g)	Match with definition	Rank of energy values
ME – specific Atwater factors	P=3.8-18.2 (0.91-4.36), CT=11.3-17.2 (2.70-4.16), F= 35.0-37.7 (8.37-9.02), A=29 (7)	5	2
ME – general Atwater factors	P=17 (4), CA and CT =17 or 16 (4 or 3.75), F= 37 (9), A=29 (7)	1	6
ME – general Atwater factors, including for dietary fibre	P=17 (4), CA and CT =17 or 16 (4 or 3.75), F= 37 (9), A=29 (7), DF=8 (2)	7	4
ME – general Atwater factors as proposed by CODEX	P=17 (4), CA and CT=17 or 16 (4 or 3.75), F= 37 (9), A=29 (7), OA=13 (3)	6	5
ME – mixed Atwater factor system	P=3.8-18.2 (0.91-4.36), CT=11.3-17.2 (2.70-4.16), F= 35.0-37.7 (8.37-9.02), A=29 (7) or P=17 (4), CT=17 or 16 (4 or 3.75), F= 37 (9)	4	3
Gross energy	P=24 (5.65), CA and CT = 17 (4), F= 40 (9.4), A=30 (7), DF=17 (4)	2	1
Net metabolizable energy	P=13 (3.2), CA=17 or 16 (4 or 3.75), F= 37 (9), A=26 (6.3), DF=6 (1.4), OA=9 (2.1)	3	7

P=protein, CA=available carbohydrates (excluding dietary fibre), CT= total carbohydrates (including dietary fibre), F=fat, A=alcohol, DF= dietary fibre; OA=organic acids

IVc.Q6 Is it advisable to publish the copied energy values from other sources in one's own user food composition database? Select the correct response. *(1 point)*

Answer:

	Publish copied energy values from other sources
	Yes, because all food composition databases use the same energy conversion factors.
	No, because all food composition databases use the same energy conversion factors but may have different macronutrient values.
x	No, because food composition databases may use different energy conversion factors and may have different macronutrient values.

For your information:
The energy values to be published should always be calculated within one's own food composition database. The energy values from other sources should be copied into the archival database for comparison only but should not become the energy values of one's own database because different energy calculation systems are used in different sources and may have a significant impact on the energy value. The contributing macronutrient values may also be different. This is the golden rule about generating energy values to be published in a food composition database.

IVc.Q7 Is it advisable to calculate kJ from kcal through the use of a conversion factor of 4.184 (rounded up to 4.2)? Select True or False. *(2 points: ½ point for each correct response)*

Answer:

True	False	Calculate kJ from kcal
x		It is not advisable to calculate kJ energy values from energy values in kcal because this may introduce bias.
x		It is recommended that the energy-yielding components be multiplied by the respective energy conversion factors in kJ.
	x	The energy conversion factors in kJ are exactly 4.184 (4.2) times higher than those in kcal.
	x	Energy conversion factors in kJ and in kcal yield exactly the same energy value when the energy calculation system is the same.

For your information:
Energy conversion factors in kJ are neither exactly 4.184 nor 4.2 times higher than energy conversion factors in kcal. Therefore, the two last responses are incorrect.

IVc.Q8 Which energy conversion factor is recommended for dietary fibre? See FAO (2003), pp. 24 and 29, available at ftp://ftp.fao.org/docrep/fao/006/y5022e/y5022e00.pdf) Select the correct answer. *(1 point)*

Answer (see Greenfield & Southgate, 2003, pp. 24 and 29 of FAO, 2003):

	Recommended energy factor for dietary fibre
	17 kJ/g (4 kcal/g)
	8.5 kJ/g (2 kcal/g)
x	8 kJ/g (2 kcal/g)

For your information:
It is presumed that fermentable fibre, with an energy value of 11 kJ/g, represents 70% of total dietary fibre in a traditional mixed diet. Non-fermentable fibre has no energy value. It should also be recognized

that some of the energy generated by fermentation is lost as gas and that some is incorporated into colonic bacteria and lost in faeces.

IVc.Q9 The energy value of 'available carbohydrates expressed in monosaccharide equivalent (CHOAVLM[15])' is 16 kJ/g (3.75 kcal/g). Why is it different to the energy value of 17 kJ/g (4 kcal/g) used for 'available carbohydrates as weight (CHOAVL)' and 'available carbohydrates by difference (CHOAVLDF)'? Select True or False. *(1.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 146):

True	False	Reasons for difference in energy conversion factors
x		The energy conversion factor of carbohydrates expressed in monosaccharide equivalent is 16 kJ/g (3.75 kcal/g), which corresponds to the energy content of monosaccharides.
x		CHOAVL and CHOAVLDF have an energy conversion factor of 17 kJ/g (4 kcal/g) because most carbohydrates in foods are polysaccharides, which have a energy content of about 17kJ/g.
x		The resulting energy values of CHOAVL, CHOAVLDF and CHOAVLM are similar because the lower energy conversion factor of 16 kJ/g (3.75 kcal/g) compensates for the higher nutrient value of CHOAVLM per 100 g edible food (owing to the larger amount of residual water around each monosaccharide compared with di- and polysaccharides).

For your information:
The energy conversion factor of 17 kJ/g (4 kcal/g) is also used for 'total carbohydrates by difference (CHOCDF)'.

IVc.Q10 In a recommended diet (55-75% carbohydrates, 10-15% protein, 15-30% fat and > 25 g dietary fibre), which nutrient makes the greatest contribution to energy intake? Select the correct answer. *(1 point)*

Answer:

	Highest energy-yielding nutrient in recommended diet
	Protein, because its amount is relatively constant in most diets.
	Fat, because it has the highest energy conversion factor.
x	Carbohydrates, because they represent the highest proportion of the energy-yielding components.
	Dietary fibre, because its energy contribution has been recognized recently.

For your information:
As the major part of most diets consists of carbohydrates, the carbohydrate expression and its energy conversion factors have the biggest impact on energy intake estimations. There are significant differences between specific and general Atwater factors for cereals, which in many countries are staple foods. The application of 17.2 vs. 17 kJ/g (or 4.12 vs. 4 kcal/g) to total or available carbohydrates can make a significant difference in energy values and, therefore, on calculations of energy intakes. When the fat intake is very high, the energy from fat can become the major energy source.

[15] The abbreviated component names in parenthesis are the INFOODS component identifiers – see Module 4.b.

IVc.Q11 As a general rule, energy values are stated as whole numbers, i.e. without decimal places. Select True or False. *(1.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 165-166):

True	False	Reason to express energy values without decimal place
	x	There is no specific reason.
x		Energy calculation is an approximation of the true energy content of the food and the use of decimal places in expressing energy values would give a false impression of accuracy.
	x	Energy conversion factors do not have decimal places; therefore, energy values do not have decimal places.

For your information:
Many significant figures before or after the decimal place give the impression of a very precise, accurate estimate of the analytical value – but this might not be the case. Therefore, care should be taken to have an adequate number of significant figures. For energy, three significant figures are recommended.

IVc.Q12 Which values and additional information should be stored in the reference database for vitamin A and β-carotene equivalents? Select True or False. *(2 points: ½ point for each correct response)*

Note: Vitamin A is commonly defined as retinol equivalent (RE) = mcg retinol + 1/6 mcg β-carotene + 1/12 other carotenes with vitamin A activity (or RE =mcg retinol + 1/6 mcg β-carotene equivalent where β-carotene equivalents = 1 β-carotene + 0.5 α-carotene + 0.5 β-cryptoxanthin).

Answer:

True	False	Information to be stored in the reference database to calculate vitamin A
x		Values of vitamin A in RE, retinol and β-carotene equivalent (in mcg)
	x	Values of total carotenes (in mcg)
x		Values of β-carotene, α-carotene and β-cryptoxanthin (in mcg)
x		Conversion factors for β-carotene, α-carotene, β-cryptoxanthin and for β-carotene equivalent to calculate β-carotene equivalent and RE, as well as the formula to calculate β-carotene equivalent and RE, should be stored in the reference database.

For your information:
Below is a list of values, conversion factors and formula needed to calculate RE and β-carotene equivalent:

- Vitamin A value in RE (in mcg)
- Retinol (in mcg)
- β-carotene equivalent (in mcg)
- β-carotene (in mcg)
- α-carotene (in mcg)
- β-cryptoxanthin (in mcg)
- Conversion factor for β-cryptoxanthin to calculate β-carotene equivalent
- Conversion factor for α-carotene to calculate β-carotene equivalent
- Conversion factor for β-carotene to calculate β-carotene equivalent
- Conversion factor for β-carotene equivalent to calculate RE
- Formula to calculate β-carotene equivalent
- Formula to calculate RE

In the past, the conversion of 6 mcg β-carotene and of 12 mcg other pro-vitamin A carotenes to 1 mcg RE was used. New evidence is emerging to indicate that each carotene in different food matrices could

have a different conversion factor and that the better general factors should be 12 and 24, respectively. If the carotene values of the pro-vitamin A carotenes and their conversion factors are stored in the database, it is easy to recalculate the value of RE using the new conversion factors. If only the value of RE were to be stored, it would be impossible to recalculate RE values using the new conversion factors.

IVc.Q13 Indicate the rounding rule that introduces the least bias. Select True or False. *(1.5 points: ½ point for each correct response)*

Answer (see also Greenfield & Southgate, 2003, p. 166):

True	False	Rounding rule with least bias
	x	Round down if the last number is 0, 1, 2, 3, 4 or 5 (e.g. 1.273 becomes 1.27). Round up if it is 6, 7, 8 or 9 (e.g. 1.278 becomes 1.28).
	x	Round down if the last digit is 0, 1, 2, 3 or 4 (e.g. 1.273 becomes 1.27). Round up if it is 5, 6, 7, 8 or 9 (e.g. 1.278 becomes 1.28).
x		Round down if the last digit is 0, 1, 2, 3 or 4 (e.g. 1.273 becomes 1.27). Round up if it is 6, 7, 8 or 9 (e.g. 1.278 becomes 1.28). For 5, round down when the number before is even and round up when it is uneven (e.g. 1.245 becomes 1.24 and 1.235 becomes 1.24).

IVc.Q14 When should rounding take place: before or after summing values? Select True or False. *(1.5 points: ½ point for each correct response)*

Answer:

True	False	Timing of rounding
	x	Rounding can be done at any time as it does not influence the final value.
x		Rounding should be done after the summation to avoid introducing additional bias.
	x	Rounding should be done before the summation to avoid introducing additional bias.

SAMPLE ANSWERS TO THE EXERCISES

IVc.E1 A cereal product has the following composition in g/100 g food:

- **fat (FAT[16]) = 8 g;**
- **protein (PROCNT/PROT) = 10 g;**
- **available carbohydrates in monosaccharide equivalent (CHOAVLM) = 45 g;**
- **total dietary fibre (FIBTG) = 5 g;**
- **alcohol (ALC) = 0 g;**
- **ash (ASH) = 5 g; and**
- **water (WATER) = 30 g.**

Complete the table below and calculate energy values in kJ using:

- the general Atwater system;
- the general Atwater system plus energy for dietary fibre;
- the general Atwater system after transforming CHOAVLM into available carbohydrates by weight (CHOAVL) ;
- the general Atwater system and total carbohydrate by difference (CHOCDF); and
- specific energy conversion factors in kJ/g (kcal/g): energy conversion factor for protein (XP) = 15.98 (3.82), energy conversion factor for fat (XF) = 35.02 (8.37), and energy conversion factor for CHOCDF (XCT) = 17.40 (4.16).

Discuss the different results. *(7.5 points: 1 point per calculation of 'Energy in kJ' and ½ point for statements following the dot (•))*

Note:

- In foods rich in starch CHOAVLM/1.1 = CHOAVL
- Use energy conversion factors as stated in IVc.Q5.

Answer:

	Energy in kJ from fat	Energy in kJ from protein	Energy in kJ from carbohydrates	Energy in kJ from fibre	Energy in kJ
(1) general Atwater system	8 x 37 =296	10 x 17 = 170	CHOAVLM 45 x 16 = 720	5 x 0 = 0	1186 kJ rounded to 1190 kJ
(2) general Atwater system plus energy for dietary fibre	8 x 37 =296	10 x 17 = 170	CHOAVLM 45 x 16 = 720	5 x 8 = 40	1226 kJ rounded to 1230 kJ
(3) general Atwater system and transforming CHOAVLM into CHOAVL	8 x 37 =296	10 x 17 = 170	CHOAVLM 45g : 1.1 = CHOAVL 40.9g x 17 = 695.5	5 x 0 = 0	1161.5 kJ rounded to 1160 kJ
(4) CHOCDF with general Atwater system	8 x 37 =296	10 x 17 = 170	CHOCDF = 100 – (FAT 8 + PROCNT/PROT 10 + ALC 0 + ASH 5 + WATER 30) = 47 x 17 =799	Fibre is included in CHOCDF	1265 kJ rounded to 1270 kJ
(5) CHOCDF with specific Atwater system	8 x 35.02 = 280.2	10 x 15.98 = 159.8	CHOCDF 47 x 17.40 = 817.8	Fibre is included in CHOCDF	1257.8 kJ rounded to 1260 kJ

[16] The abbreviated component names in parenthesis are the INFOODS component identifiers – see module 4.b.

Discussion:
(•) There is a difference of 70 kJ between lowest and highest energy calculations for the same food. (•) This can introduce bias in the energy intake calculation, (•) especially if it is a staple food or highly consumed. This exercise shows that the (•) energy of fibre diminishes the differences between the different calculations, and that (•) carbohydrate value and definition contribute most to the differences in the energy value.

For your information:
Energy values should never be copied and used as the energy value of foods in one's own database, especially if the macronutrient values are obtained from different sources.

IVc.E2 Indicate the nitrogen-to-protein conversion factors for the following foods, according to Jones as cited in Greenfield and Southgate (2003). *(3 points: ¼ point for per each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 103):

Foods	Nitrogen-to-protein conversion factors
Pork chop	6.25
Fresh cheese	6.38
Bread	if with white wheat flour – 5.7; whole wheat – 5.83; mixture of whole wheat and rye – 5.83
Sorghum	6.31 (of millet)
Spaghetti	if with white wheat flour – 5.7; with whole wheat – 5.83
Spaghetti with tomato sauce, minced beef meat and cheese	6.25 (if the default value is taken. If not a weighted mean based on the different ingredients should be calculated – or for recipes no nitrogen-to-protein conversion factor should be stated but only the protein and nitrogen values)
Walnut	5.3
Sea bass	6.25
Dried peas	6.25
Potato	6.25
Infant formula	6.38 if based on milk powder; and 5.71 if based on soya
Chocolate	6.25

For your information:
For recipes, it is difficult to attribute a nitrogen-to-protein conversion factor. Probably the general factor of 6.25 is appropriate.

If the food description is not sufficiently precise, it may be difficult to attribute the correct conversion factor. It is however possible to calculate the protein value for all foods because a default value of 6.25 is available.

IVc.E3 Indicate the fatty acid conversion factors for the following foods. *(4 points: ¼ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 223):

Food	Fatty acid conversion factors
Bread	0.67 (from wheat, barley and rye flour)
White rice	0.85 (from milled rice)
Potato	0.8 (from vegetables and fruit)
Beef	0.916 if lean or 0.953 if fatty
Beef liver	0.741
Bacon	0.953 (of fat pork)
Chicken	0.945 (of poultry)
Sea bass	0.7 (from white fish – assumption of lean means up to 5% fat)
Mussel	0.7 (from white fish – assumption of lean means up to 5% fat and applies to molluscs)
Coconut oil	0.942
Margarine	0.956 (from fats and oil, all except coconut)
Milk	0.945 (from milk and milk products)
Mayonnaise	0.956 (from fat and oil)
Ketchup	0.8 (from vegetables and fruits)
Ice cream	0.945 (from milk and milk products if dairy ice cream) or 0.956 (from fat and oil if non-dairy ice cream)
Chocolate	0.956 (from fat and oil)

For your information:
Fatty acid conversion factors (XFA) are published for a few foods only and no default fatty acid conversion factor is available. However, as total fat is analysed, XFA is not needed to calculate the total fat value.

In some cases, the list of fatty acid conversion factors (XFA) does not include the food for which a factor is sought – therefore an estimation must be made. However, it is best to calculate XFA from analytical data of the specific food.

IVc.E4 The following vitamins include expressions that are calculated. Calculate the nutrient values in the unit and denominator indicated in the table by using the information provided.
(20 points: 1 point for each correct calculation)

(a) β-carotenes equivalent

Values in mcg/100 g edible food except where indicated
Red sweet pepper: β-carotene = 3170; α-carotene = 135; β-cryptoxanthin = 1220; α-cryptoxanthin = 10; water 90.4 g/100 g edible food; edible portion 83%

Express values as whole numbers with three significant digits.

Answer:

β-carotenes equivalent definitions	Nutrient value in mcg/100 g edible food
= 1 β-carotene + 0.5 α-carotene + 0.5 β-cryptoxanthin	3850 (rounded from 3847.5)
= 1 β-carotene + 0.5 α-carotene + 0.5 β-cryptoxanthin + 0.5 α-cryptoxanthin	3850 (rounded from 3852.5)

Calculations
3170 + 0.5 x (135 + 1220) = 3847.5
3170 + 0.5 x (135 + 1220 + 10) = 3852.5

(b) Vitamin A

Values in mcg/100 g dry matter of edible portion except where indicated
Kidney, ox, raw: β-carotene equivalent = 2050; retinol = 525; all-*trans* retinol = 450; 13-*cis* retinol = 100; retinaldehyde = 0; water = 80 g/100 g edible food; edible portion 88%

Express values as whole numbers.

Note: All-*trans* retinol equivalents = all-*trans* retinol + 0.75 13-*cis* retinol + 0.90 retinaldehyde (used in United Kingdom)

Answer:

Vitamin A	Nutrient value in mcg/100 g edible food
RE (Retinol equivalent) = mcg retinol + 1/6 mcg β-carotene + 1/12 mcg other provitamin A carotenoids	173 (rounded from 173.3)
RE (Retinol equivalent) = mcg retinol + 1/6 mcg β-carotene equivalent	173 (rounded from 173.3)
RAE (retinol activity equivalent) = mcg retinol + 1/12 mcg β-carotene + 1/24 mcg other provitamin A carotenoids (USDA, NEVO)	139 (rounded from 139.16)
RE = mcg all-*trans* retinol equivalents + 1/6 mcg β-carotene equivalent	173 (rounded from 173.3)

Calculations

Values in mcg/100 g edible portion
All values are transformed from 100 g dry matter to 100 g edible food by dividing the nutrient values by 5 (= 20/100) because if water is 80 g/100 g edible food, dry matter is 20 g/100 g edible food.
Kidney, ox, raw: β-carotene equivalent = 410; retinol = 105; all-*trans* retinol = 90; 13-*cis* retinol = 20; retinaldehyde = 0; water = 80 g/100 g edible food

105 + (410/6) = 173.3
105 + (410/6) = 173.3
105 + (410/12) = 139.16
90 + (0.75 x 20) + (410/6) = 173.3

For your information:
The Danish food composition database uses the same formula as RAE but calls it RE.

(c) Vitamin D

Values in mcg/100 g total food except where indicated
Sausage, salami, raw: ergocalciferol (vitamin D_2) = 0; cholecalciferol (vitamin D_3) = 0.306; 25-hydroxycholecalciferol = 0.135; water = 28.7 g/100 g edible food; edible portion 90%

Express values with two figures after the decimal place.

Answer:

Vitamin D definitions	Nutrient value in mcg/100 g edible food
= ergocalciferol (vitamin D_2) + cholecalciferol (vitamin D_3) (used in most food composition databases)	0.34
= cholecalciferol (vitamin D_3)	0.34
= Vitamin D_2 + D_3 + 5 x 25-hydroxycholecalciferol (used in United Kingdom, Denmark)	1.08 (rounded from 1.085)

Calculations

Values in mcg/100 g edible portion
All values are transformed from per 100 g total food to per 100 g edible food:
value x 100/90 because edible portion is 90%, meaning that 10% of the total food does not contain the component (total food = edible + inedible portion).
Sausage, salami, raw: ergocalciferol (vitamin D_2) = 0; cholecalciferol (vitamin D_3) = 0.34; 25-hydroxycholecalciferol = 0.149; water = 28.7 g/100 g edible food; edible portion 90%

0 + 0.34 = 0.34
0.34
0.34 + (5 x 0.149) = 1.085

(d) Vitamin E

Values in mcg/100 g edible food except where indicated
Palm oil: α-tocopherol = 25600; β-tocopherol = 10; γ-tocopherol = 31600; δ-tocopherol = 7000; α-tocotrienol = 14300; β-tocotrienol = no data; γ-tocotrienol = no data; water 0.0 g/100 g edible food; edible portion 100%

Express values with two figures after the decimal place.

Answer:

Vitamin E definitions	Nutrient value in mg/100 g edible food
α-tocopherol (TOPHA[17]). DRI (2001) found that only TOPHA and 3 synthetic forms have vitamin E activity (USDA SR16 and later)	25.60
α-TE (VITE) = α-tocopherol + 0.4 β-tocopherol + 0.1 γ-tocopherol + 0.01 δ-tocopherol + 0.3 α-tocotrienol + 0.05 β-tocotrienol + 0.01 γ-tocotrienol (UK and most others)	33.12 (rounded from 33.124)
α-TE (VITE) = α-tocopherol + 0.5 β-tocopherol + 0.1 γ-tocopherol + 0.3 α-tocotrienol	33.06 (rounded from 33.055)
α-TE (VITE) = α-tocopherol + 0.4 β-tocopherol + 0.1 γ-tocopherol + 0.01 δ-tocopherol (NEVO)	28.83 (rounded from 28.834)
α-TE (VITE) = α-tocopherol + 0.5 β-tocopherol + 0.25 γ-tocopherol + 0.3 α-tocotrienol (D-A-C-H)	37.80 (rounded from 37.795)

Calculations

All values are divided by 1,000 to transform them from mcg to mg
Palm oil: α-tocopherol = 25.60; β-tocopherol = 0.01; γ-tocopherol = 31.60; δ-tocopherol = 7.00; α-tocotrienol = 14.30; β-tocotrienol = no data; γ-tocotrienol = no data; water 0.0 g/100 g edible food; edible portion 100%

25.60
25.60 + (0.4 x 0.01) + (0.1 x 31.60) + (0.01 x 7.00) + (0.3 x 14.30) + 0 + 0 = 33.124 (treating missing data as zero value)
25.60 + (0.5 x 0.01) + (0.1 x 31.60) + (0.3 x 14.30) = 33.055
25.60 + (0.4 x 0.01) + (0.1 x 31.60) + (0.01 x 7.00) = 28.834
25.60 + (0.5 x 0.01) + (0.25 x 31.60) + (0.3 x 14.30) = 37.795

(e) Niacin and niacin equivalent

Values in mg/100 g edible food except where indicated
Cod fish, baked: niacin = 2.3; tryptophan (TRP) = 240.0; water 76.6 g/100 g edible food; edible portion 85%

Express values with one figure after the decimal place

Answer:

Niacin and niacin equivalent definition	Nutrient value in mg/100 g edible food
Niacin	2.3
Niacin equivalent = niacin + 1/60 TRP	6.3

Calculations
2.3
2.3 + (240.0/60) = 6.3

17 The abbreviated component names in parenthesis are the INFOODS component identifiers – see Module 4.b.

For your information:
In cases of limited protein supply or when TRP is s limiting amino acid in the diet, it is not totally available for niacin activity.

(f) Folate including dietary folate equivalent

Values in mcg/100 g edible food except where indicated
Cornflakes, fortified: folic acid = 338; (food) folate = 19

Express values without a decimal place

Answer:

Folate expressions	Nutrient value in mcg/100 g edible food
Folic acid = synthetic form used in fortification	338
Total folate (= food folate + folic acid). Includes both conjugated and free folate	357
Folate food, naturally (=food folate used in USDA)	19
Dietary folate equivalent (FOLDFE in mcg) = food folate (pteroylpolyglutamates) + 1.7 x synthetic folic acid (pteroylmonoglutamic acid) (used in USDA)	594 (rounded up from 593.6)

Calculations
338
338 + 19 = 357
19
19 + (1.7 x 338) = 593.6

Optional question for those with advanced knowledge or who have participated in a food composition course
IVc.E5 Available carbohydrates are often defined as the sum of sugars (mono- and disaccharides) and polysaccharides. Glycogen and oligosaccharides are often not included. Indicate the foods for which the exclusion of glycogen and oligosaccharides might result in a significantly lower value of available carbohydrates. Select True or False. *(2 points: ½ point for each correct response)*

Answer:

True	False	Significantly lower value of available carbohydrates due to exclusion of glycogen and oligosaccharides
x		Liver
x		Legumes
	x	Wheat flour
	x	Lobster

For your information:
Liver has a high amount of glycogen and legumes a high amount of oligosaccharides. Wheat flour and lobster have little or no glycogen or oligosaccharides.

IVc.E6 The following table shows fatty acid values as a percentage of the sum of fatty acids. Select the food that would have the lowest value for total saturated fatty acids (FASAT) in the food composition database as compared to the true content in the food, if only F4D0, F16D0 and F18D0 were analysed and included in FASAT. *(1 point)*

	Chicken (flesh only)	Cream	Duck (flesh & skin)	Duck (flesh only)	Eddible tallow (beef)	Eddible tallow (mutton)	Egg (chicken)
C4:0		3.5					
C6:0		2.1					
C8:0		1.2					
C10:0		2.8					
C12:0	0.3	3.1	0.2	0.4	0.9		
C14:0	0.9	11.1	0.7	0.5	3.7	3.8	0.3
C16:0	22.1	28.8	25.9	26.2	24.9	21.5	26.6
C16:1 n-7	5.5	2.5*	4.3	4.6	4.2	2.3	4.0
C17:0							
C17:1							
C18:0	7.7	13.3	9.2	13.7	18.9	19.5	9.3
C18:1 n-9	34.7	27.6*	43.9	34.8	36.0	37.6	44.1
C18:2 n-6	26.5	2.5	12.8	13.9	3.1	5.5	13.4
C18:3 n-3	1.1	1.6	1.1	1.5	0.6	2.3	
C20:1 n-9	0.6				0.3		
C20:4 n-6	1.7						1.0
C20:5 n-3	0.2						
C22:0							
C22:1 n-9							
C22:1 n-6							
C22:6 n-3	0.6						
Source	USDA	USDA	USDA	USDA	USDA	USDA	USDA

Answer:

Foods	FASAT value is the lowest compared to the real composition if only F4D0, F16D0 and F18D0 included
Chicken (flesh only)	
Cream	x
Duck and skin	
Edible tallow (beef)	
Edible tallow (mutton)	
Egg (chicken)	

For your information:
User databases or tables might include different fatty acids in the fatty acid fractions without necessarily indicating in their documentation the specific fatty acids which are included in the fatty acid fractions. This might be one of the reasons why different food composition tables and databases have different values for the same or similar foods. Other reasons for differences in fatty acid composition might be e.g. feed, season, animal or breed.

GENERAL FEEDBACK USING SELF-SCORING

51 – 68.5 points: You have understood and integrated the principles of component conventions and expressions. Congratulations. You are well prepared to proceed to the next module and to apply the new knowledge.

36 – 50 points: You have understood and integrated most of the principles of component conventions and expressions. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so in order to effectively apply the new knowledge.

17 – 35 points: You have understood and integrated a fair part of the principles of component conventions and expressions. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so in order to effectively apply the new knowledge.

0 – 16 points: You appear to have significant gaps in your understanding of the principles of component conventions and expressions. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

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Module 4.d

METHODS OF ANALYSING COMPONENTS

LEARNING OBJECTIVES

By the end of this module the student will:

- have acquired a basic knowledge of available analytical methods for food analysis;
- be aware of the analytical methods available per component and of their limitations and application;
- understand the impact of analytical methods on data quality and on component values;
- understand the relationship between component identification through tagnames (see module 4.b) and analytical methods;
- know which analytical methods are recommended for food composition work;
- comprehend the impact of analytical methods on data quality and component value;
- be able to select an appropriate laboratory performing the right analytical methods;
- be able to select data which is determined with an appropriate method for food composition work.

REQUIRED READING

- **Annor, G.A.** Proximate System of Analysis. PowerPoint Presentation. Available at: http://www.fao.org/infoods/presentations_en.stm
- **Greenfield, H. & Southgate, D.A.T**. 2003. *Food composition data – production, management and use*. FAO, Rome[18]. Chapters 5 (p. 72), 6 (pp. 85, 91-96) and 7 (pp. 97-148, in particular pp. 98, 100, 104, 108, 112, 114, 116, 122, 124, 126, 136 and 137). Available at ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf)

EXERCISE MATERIAL

- **Klensin, J.C., Feskanich, D., Lin, V., Truswell, S.A. & Southgate, D.A.T**. 1989. *Identification of Food Components for INFOODS Data Interchange*. UNU, Tokyo. pp. 16-91. Available at http://www.unu.edu/unupress/unupbooks/80734e/80734E00.htm and as PDF file at: ftp://ftp.fao.org/es/esn/infoods/Klensinetal1989Identificationoffoodcomponents.pdf
- A set of updated tagnames, including the 2003 update. Available at http://www.fao.org/infoods/tagnames_en.stm
- International Union of Pure and Applied Chemistry (IUPAC) Compendium of Chemical Terminology - the Gold Book'. Available at *http://goldbook.iupac.org/index.html*),
Website of the Department of Chemistry, University of Adelaide, Australia. Available at http://www.chemistry.adelaide.edu.au/external/soc-rel/content/ac-meths.htm
- Wikipedia: http://en.wikipedia.org/wiki/Main_Page
- **Monro, J. & Burlingame, B.** 1996. Carbohydrates and related food compounds: INFOODS tagnames, meanings, and uses. *Journal of Food Composition and Analysis* 9, pp. 100–118 (see, in particular, p. 109). Available at: http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%236879%231996%23999909997%23307729%23FLT%23&_cdi=6879&_pubType=J&_auth=y&_acct=C000055286&_version=1&_urlVersion=0&_userid=6718006&md5=5758f2861be3a2fcfda26c5c3bed752e

RECOMMENDATION

It is recommended that students complete module 4.b (Component nomenclature) before starting on the present one and complete modules 6 (Quality aspects of analytical data) and 11 (Quality considerations in data compilation) in conjunction with this module.

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users ++
- Analysts +++++

[18] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to the PDF file.

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 3-8 hours
- Answering the questions: 1-4 hours
- Completing the exercises: 1-4 hours

SUGGESTED ADDITIONAL READING

For more detailed information on methods, it is recommended that students consult:

- **List of essential books** for food composition databases (appendix 7, pp. 226-228), in Greenfield & Southgate (2003)
- **Association of Analytical Communities (AOAC)**: recent publications on AOAC methods, available at http://eoma.aoac.org/
- **CEN** (European Committee for Standardization) standards: CEN/TC 275 Food analysis - Horizontal methods, e.g. CEN/TC 275 WG 9 – Vitamins and Carotenoids. Available at http://www.nal.din.de/gremien/CEN%2FTC+275/en/54740484.html

Answers to the questions

IVd.Q1 Explain why compilers need to understand the principles underlying the selection of analytical methods, analytical methods per se, and laboratory quality assurance and quality control schemes. Select True or False. *(4.5 points: ½ point for each correct response)*

Answer:

True	False	Compilers should have a basic knowledge of analytical methods to be able to:
x		select an appropriate laboratory.
x		understand the differences in nutrient values due to analytical methods.
x		document analytical methods for food composition data in an appropriate manner.
	x	carry out chemical analysis.
x		judge the quality of nutrient values.
x		discuss analytical results with analysts.
	x	develop an appropriate sampling plan.
	x	calculate recipes.
x		select appropriate analytical methods.

IVd.Q2 Match the following terms to the corresponding description. *(10.5 points: ½ point for each correct response).*

Note: It may be helpful also to consult the IUPAC Compendium of Chemical Terminology - the Gold Book' (available at *http://goldbook.iupac.org/index.html*), the website of the Department of Chemistry, University of Adelaide, Australia (http://www.chemistry.adelaide.edu.au/external/soc-rel/content/ac-meths.htm), or Wikipedia (http://en.wikipedia.org/wiki/Main_Page). Another useful resource may be the table under question IVd.E3.

Expressions related to analytical methods:

1. Proximates
2. Obsolete analytical methods
3. Recommended analytical methods
4. Indirect measurements
5. Saponification
6. Solvent extraction
7. Volatile compounds
8. Hydrolysis
9. Interference

Answer (see Greenfield & Southgate, 2003, pp. 97, 99 and references under note):

Number of term	Description
7	They are organic compounds such as aldehydes, ketones, halogenide and sulfide, formaldehyde and other light hydrocarbons, that may evaporate at normal temperature and pressure.
2	These methods generate data that does not correspond to current standards and knowledge, and/or should no longer be used.
9	They cause error in the measurement of a signal because of their presence in a sample.
5	This is a reaction of a metallic alkali (base) with a fat or oil to form soap. The ester is hydrolysed under strong basic conditions to form an alcohol and the salt of a carboxylic acid. It is required before the sample is analysed for fat related components to obtain a reliable value (e.g. for fatty acids, cholesterol, carotenoids, and vitamins A, D and E).
1	They originally consisted of analytical determinations of water (moisture), ash, crude fat (ether extract), crude protein and crude fibre. Nitrogen-free extract (NFE), more or less representing sugars and starches, was calculated by difference rather than measured by analysis. This definition was subsequently adapted for food compositional purposes.
6	This is a separation method whereby one or several suitable solvents remove one or more soluble components from a mixture. By means of this process, a soluble compound is usually separated from an insoluble compound based on their relative solubilities. Several techniques are available: single-stage, multi-stage counter current continuous processes with or without chemical change, ion exchange mechanism, aqueous two-phase, or continuous process (e.g. Soxhlet).
3	These methods generate data in accordance with current standards and knowledge. Even when several methods exist, this particular method is considered optimal.
8	This is a reaction used to break down certain polymers before analysis. These reactions may be catalysed by acid, alkali or enzymes. It is used before the determination of fatty acids, amino acids and starch.
4	These methods determine the content of the component to be measured through analysis of another component (e.g. protein through total nitrogen measurement).

For your information:
The proximate system is still used. Originally, it formed the basis of feed analysis. In a slightly modified form, it is used by the USDA for the components water, ash, protein, fat and total carbohydrates calculated by difference. Many people find it convenient to represent the major food components in this system. Atwater derived his energy conversion factors from the proximate system. As crude fibre is considered obsolete, proximates are often now defined as water, ash, protein, fat, (total or available) carbohydrates and dietary fibre.

Analytical method types:

1. High-performance liquid chromatography (HPLC)
2. Gas-liquid chromatography (GLC), also called gas chromatography (GC)
3. Colorimeter
4. Atomic absorption spectroscopy (AAS)
5. Inductively coupled plasma spectrometry (ICP)
6. Flame photometry
7. Fluorometry (fluorescence spectroscopy or spectrofluorometry)
8. Titrimetry/titration
9. Bioassay
10. Microbiological method
11. Gravimetric analysis
12. Mass spectrometer (MS)

Answer (see references under note):

Number of analytical method	Description of analytical method types
6	The method uses emission spectroscopy in the ultraviolet and visible regions to identify and estimate the amounts of various minerals excited in a flame, an arc or high voltage spark.
3	The method uses a device to test the concentration of a solution by measuring its absorbance of a specific wave length of light. Important issues are calibration, size of the filter and wave length of the light.
12	It is an analytical technique for the determination of the elemental composition of a sample or molecule. Its principle consists of ionizing chemical compounds to generate charged molecules or molecule fragments and measurement of their mass-to-charge ratios. It can be used alone or in combination with other instruments.
1	The method is a separation technique in which the mobile phase is a liquid. It can be carried out in a column. In general, it uses very small particles and a relatively high inlet pressure, and is used extensively in food composition (e.g. fatty acids, amino acids, sugars, polyols, oligosaccharides, vitamins and many non-nutrients).
8	The method determines the quantity of a substance *A* by gradually adding known concentrations of another substance *B* with provision for some means of indicating the *endpoint,* at which essentially all of *A* has reacted with B. The amount of *A* to be calculated from the known amount of *B* added up to this endpoint and the reacting weight ratio of *A* to *B should be* known from stoichiometry or otherwise. The method can be used for vitamin C, calcium, magnesium and protein – even though it is not the preferred method for any of these compounds.
10	In this method, micro-organisms are used to determine the concentration of a compound. This method type is mostly used for B vitamins.
5	This method is capable of determining simultaneously a range of metals and several non-metals but is highly expensive. If it is coupled with mass spectrometer, the method is highly sensitive even at low concentrations and can determine isotopic speciations.
7	The method is a type of electromagnetic spectroscopy that analyses fluorescence from a sample. It involves using a beam of light, usually ultraviolet light, that excites the electrons in molecules of certain compounds and causes them to emit light of lower energy, typically, but not necessarily, visible light. It can be used to determine vitamin C, thiamin or riboflavin.
11	The method is used for the quantitative determination of an analyte based on its mass in a solid form. The analyte can be removed from a solution or from the food through filtration or vaporization and then weighed; or it must first be converted to a solid by precipitation with an appropriate reagent. The precipitate can then be collected by filtration, washed, dried to remove traces of moisture from the solution, and weighed. The amount of analyte in the original sample can then be calculated from the mass of the precipitate and its chemical composition. This is used for water, dietary fibre (Prosky method) or sulphur.
4	The method is a technique for determining the concentration of a particular mineral in a sample. The electrons of the atoms in the atomizer can be promoted to higher orbitals for an instant by absorbing a specific quantity of energy (i.e. light of a given wave length). This amount of energy (or wave length) is specific to a particular electron transition in a particular element and, in general, each wave length corresponds to only one element. This gives the technique its elemental selectivity.
9	The method is a procedure for determining the concentration or quality or activity of a substance (e.g. vitamin, amino acids) by measuring its effect on an organism or tissue compared with a standard preparation. It has been used to determine vitamin activities (vitamins A, D and E) and is still used for protein quality (e.g. PER, NPU).
2	The method is a type of chromatography in which the mobile phase is a carrier gas, usually an inert gas such as helium or an unreactive gas such as nitrogen. The stationary phase is a microscopic layer of liquid or polymer on an inert solid support inside a column. The interactions of these gaseous analytes with the walls of the column (coated by different stationary phases) cause different compounds to elute at different times, called retention time. The comparison of these retention times is the analytical power of this technique, which is used, for example, in the analysis of fatty acids, alcohol, sugars, polyols, oligosaccharides, iodine, and vitamins D, E and C.

IVd.Q3 The main purpose of analytical methods is to separate, identify and quantify compounds. From the following list select the one which is not a principle for separating compounds for analysis. *(1 point)*

Answer:

	Not a principle for separation of compounds for analysis
	Solubility
	Polarity
	Volatility
x	Function in the human body

IVd.Q4 One way of ascertaining whether methods provide comparable results is to look up the number of INFOODS tagnames for the same component. Select True or False. *(2 points: ½ point for each correct response)*

Note: See introduction of Klensin *et al.* (1989), available at: http://www.unu.edu/unupress/unupbooks/80734e/80734E00.htm and the INFOODS website with updated tagnames at http://www.fao.org/infoods/tagnames_en.stm

Answer:

True	False	Relation between number of tagnames and comparability of analytical methods
	x	Food components for which the different analytical methods give significantly different results have the same tagname.
x		Component values of the same tagname are comparable; those of different tagnames are not comparable.
x		Rational methods, i.e. different analytical methods generating similar results, have one tagname. For components with rational methods, the compiler/user may use the values without investigating analytical methods.
x		Empirical methods, i.e. different analytical methods generating significantly different results, have several tagnames. For these methods the analyst, compiler and user should know which analytical method is recommended for food composition work and which analytical methods provide compatible results.

For your information:
Another issue for comparability of values is that energy and some nutrients (e.g. α-tocopherol equivalent), even though having the same tagname, can have different values due to several ways of calculating nutrient values, i.e. different nutrient definitions. In such cases, additional information as keywords (contributing components and conversion factors) needs to be consulted to ascertain comparability of values.

IVd.Q5 If for the same component, several tagnames exist, it means that either the expression is different (e.g. carbohydrates) or that there are several analytical methods (e.g. fibre) leading to significantly different values. Indicate for the nutrients in the following table (1) whether methods provide comparable results, (2) if there are several tagnames, and (3) if there are different calculations and expressions. Select Yes or No. *(42 points: ½ point for each correct response)*

Note: See Klensin *et al.* (1989), available at: http://www.unu.edu/unupress/unupbooks/80734e/80734E00.htm and the INFOODS website with updated tagnames at http://www.fao.org/infoods/tagnames_en.stm

Answer (see chapter 7, Klensin *et al.*, 1989, and INFOODS website on tagnames):

Food component names		Do methods give comparable results?[19] Yes/No	Are there several tagnames? Yes/No	Do different calculations or expressions exist? Yes/No
Water		No (if freeze drying not done carefully) /yes	No (WATER)	No
Total fat		No	Yes (FAT; FATCE; FATNLEA)	No
Individual fatty acids (FA)		Yes	--- (Each fatty acid has one)	No
Fractions of FAs, e.g. saturated fatty acids		---	--- (FASAT, FAPU; FAMS; FATRN)	Yes (not always the same FAs are included in the sum)
Cholesterol		No	Yes (CHOLE; CHOLC; CHOL-)	No
Protein		No	Yes (PRO-; PROCNA; PROCNP; PROCNT/PROT)	Yes
Total nitrogen		Yes	No (NT)	No
Individual amino acids		Yes	--- (Each amino acid has one)	No
Individual sugars		Yes	--- (Each monosaccharide has one; starting with disaccharide, all have two tagnames)	Yes
Sugar		Yes	Yes (SUGAR; SUGARM)	Yes
Individual polyols		Yes	--- (Each polyol has one)	No
Oligosaccharides		Yes	Yes (e.g. OLSAC; OLSACM)	Yes
Starch		Yes	Yes (STARCH; STARCHM)	Yes
Dietary fibres		No	Yes (FIBTG; FIBTS; FIBAD; FIBND; FIBSOL; FIBINS; FIBC; FIB-; PSACNS/NSP)	No
Resistant starch		---	--- (STARES. Being added: STARES1, STARES2, STARES3, STARES4)	No
Alcohol (ethylalcohol or ethanol)		Yes	No (ALC)	No
Inorganic constituents		Yes	--- (e.g. ASH; K)	No
	Retinol	Yes	No (RETOL, RETOLEQ)	Yes
	Carotenes/ Carotenoids	Yes (for modern methods)/no (because of the Carr and Price method, now obsolete)	--- (Each carotene has one: e.g. CARTA; CARTB. CARTBEQ, LYCPN)	No
	Vitamin A (activity)	No[1]	Yes (VITA; VITA_RAE, VITAA; VITA-)	Yes
	Vitamin D	No[1]	Yes (VITD; VITDEQ, VITDA; VITD-)	Yes
	Vitamin E	No[1]	Yes (VITE; VITEA; VITE-)	Yes
Vitamins	**Vitamin K**	Yes	No (VITK)	No
	Vitamin C	No	Yes (VITC; ASCL)	Yes
	Thiamin	Yes	No (THIA)	No
	Riboflavin	Yes	No (RIBF)	No
	Niacin	Yes	Yes (NIA, NIAEQ)	Yes
	Vitamin B_6	No	Yes (VITB6A; VITB6C; VITB6-)	No
	Folate(s)	No[2]	Yes (FOL; FOLAC; FOLDFE, FOLSUM)	Yes
	Panthothenic acid	Yes	No (PANTAC)	No
	Biotin	Yes	No (BIOT)	No
	Vitamin B_{12}	Yes	No (VITB12)	No

1 Bioassays available for vitamins A, D, and E do not provide comparable results. However, bioassays are regarded as obsolete for most vitamins – although probably less so for vitamin D. Therefore, the response 'Yes' is also correct; but the different expressions provide different values, thus different tagnames.

2 The microbiological method may provide significantly higher values compared with HPLC because the latter does not capture all vitamers.

19 This question aims to identify components for which the results depend on method performance, i.e. the ability of the method to measure the specific component(s) contributing to the nutrient.

IVd.Q6 Which nutrient should always be analysed? *(1 point)*

Answer (pp. 72, 99):

Water

For your information:
Water should always be analysed when other nutrients are determined because all other nutrient contents depend on the water value. It is also a useful measure for checking the food description and allowing for verification and adjustment of other nutrient values.

IVd.Q7 Which analytical method may provide non-comparable water values? Select the correct response. *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 98-99):

	Analytical method that may provide non-comparable water values
x	Freeze-drying
	Oven-drying
	Microwave oven-drying
	Dean and Stark distillation

For your information:
With freeze-drying some residual water usually remains in the sample when used as sample preparation, resulting in lower water values. The other methods have pitfalls: samples may boil when microwaved or volatiles may be lost in distillation.

For learners with advanced knowledge
IVd.Q8 The classical analytical method for alcohol is distillation. Name the two other methods for measuring alcohol. Indicate one advantage of each method compared with the classical method. *(2 points: 1 point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 121):
1. Gas liquid chromatography (advantages: simpler and quicker)
2. Enzyme procedure using alcohol dehydrogenase (advantage: there is no risk of interference with other volatile components)

For learners with advanced knowledge

IVd.Q9 Select the principles and advantages/disadvantages corresponding to the Kjeldahl or the Dumas method. *(3 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 101-102):

Principles and advantages/disadvantages	Kjeldahl method	Dumas method
It measures the total nitrogen as nitrogen gas after a complete combustion of the food.		x
Measures the total nitrogen in the food by decomposition of organic samples using concentrated acid solution in presence of a catalyst, adding excess base to the acid digestion to convert ammonium to ammonia followed by boiling and condensation of the ammonia gas in the receiving solution. This is titrated to quantify the amount of nitrogen.	x	
It has high costs.		x
It is environment-friendly.		x
It needs a fume hood.	x	
It provides separate values for total nitrogen and non-protein nitrogen.		

For your information:
Both methods provide total nitrogen, but no non-protein nitrogen values.

IVd.Q10 Different empirical analytical methods generate different nutrient values for the same component in the same food. See the example of crude vs. dietary fibre (NSP) in the table below. Indicate the impact of the two methods on fibre intake, adequacy and requirement. Select True or False. *(2.5 points: ½ point for each correct response)*

Foodstuff	Crude fibre (g)	Dietary fibre (g)
Cereals and millets		
Rice	0.2	4.1-8.3
Wheat	1.2	11.4-17.2
Sorghum	1.6	9.7-14.3
Bajra	1.6	11.8-20.3
Ragi	3.6	11.5-18.6
Pulses and legumes		
Green gram (whole)	4.1	15.2
Green gram (dhal)	0.8	13.5
Green gram (dhal)	0.9	14.3
Red gram (dhal)	1.5	14.1
Bengal gram (whole)	3.9	26.6
Bengal gram (dhal)	1.2	13.6
Nuts and oil seeds		
Groundnut	3.1	6.1
Coconut (dry)	6.6	8.9
Roots and tubers		
Sweet potato	0.8	7.3
Potato	0.4	4.0
Yam	0.8	5.3
Fruits		
Banana	0.4	2.5
Mango	0.7	2.3
Vegetables		
Amaranth	1.0	3.4
Palak	0.6	5.0
Brinjal	1.3	2.0
Ridge gourd	0.5	5.7
Snake gourd	0.8	1.8
Bottle gourd	0.6	2.8
Yellow pumpkin	0.7	0.5

Source: Modified from Rao, 2003[20]

[20] Rao, B. N., 2003. Bioactive phytochemicals in Indian foods and their potential in health promotion and disease prevention. *Asia Pacific J Clin Nutr 2003: 12 (1): 9-22*

Answer:

True	False	Impact of the two methods on fibre intake estimations, adequacy and requirement
x		For some nutrients (e.g. analysed with empirical methods) the analytical method used influences the percentage of the population reaching dietary adequacy.
	x	There is little impact on the fibre intake estimations because the fibre content in foods is low.
x		The recommended daily intake (RDI) for fibre might be too low if based on the mean fibre intake of the population, calculated with crude fibre values.
x		Erroneous decisions may have been taken in nutrition and health programmes because of inadequate nutrient values in the food composition table - probably determined by an inadequate method.
x		Only recommended analytical methods should be used in food composition databases to allow for better estimation of nutrient intakes and of dietary adequacy/inadequacy.

For learners with advanced knowledge

IVd.Q11 When amino acids are analysed, acid hydrolysis leads to a loss of some amino acids. Name the five amino acids that are partially or completely degraded or lost in acid condition. *(2.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 105-106):

Amino acids that are:

- completely degraded or lost with acid hydrolysis: tryptophan;
- partially degraded or lost with acid hydrolysis: threonine, serine, cystine and methionine

For learners with advanced knowledge

IVd.Q12 How can the concentration of these five amino acids be determined? *(3 points: 1 point for each correct response following (•))*

Answer (see Greenfield & Southgate, 2003, p. 105-106):

(•) Cystine and methionine are usually protected by specific oxidation before hydrolysis;
(•) Considering that threonine and serine degrade time-dependently, it is possible to measure their initial quantity by performing series of hydrolyses during three time periods: 24, 38 and 48 hours;
(•) Tryptophan should be determined after alkaline hydrolysis.

For your information:
Serine and threonine are slowly degraded in acid; after 20 hours, expected losses can be of the order of 10 and 5%, respectively.
Cysteine and cystine are determined separately after derivatization, or may be analysed as cysteic acid after oxidation.

IVd.Q13 What are the important considerations for fat analysis? Select True or False. *(2 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 107):

True	False	Important considerations for fat analysis
	x	The continuous extraction method (Soxhlet method) is recommended for food composition and applicable to all foods.
x		Check that acid hydrolysis is carried out before the fat determination (if not, depending on the food matrix, the fat value may be too low).
x		The Soxhlet method provides values that are too low for cereal-based foods. It may, however, be used for non-cereal-based foods.
	x	Extracts from the Soxhlet method may be used for fatty acid analyses.

For your information:
Because the Soxhlet method provides non-comparable results for cereals it has a different tagname (FATCE). All other methods, because they provide comparable results, are grouped under the tagname FAT.

IVd.Q14 The value of 'total fat' is higher, lower than, or equal to the sum of fatty acids? Select the correct answer. *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 223):

	Value of 'total fat' compared to the sum of fatty acids
x	The analytical value of 'total fat' is higher than the sum of fatty acids because the fat value includes glycerol, phospholipids and unsaponifiable components such as sterols. These components are not included in the sum of fatty acids.
	The analytical value of 'total fat' is lower than the sum of fatty acids because of the fatty acid conversion factor.
	The analytical value of 'total fat' is the same as the sum of fatty acids because the individual fatty acids are summed up to build the total fat value.

IVd.Q15 The analysis of vitamins presents a challenge for analysts. Indicate the correct statements on vitamin analysis. Select True or False. *(3 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 126- 127, 136-137):

True	False	Challenges in vitamin analysis
x		As some vitamins are sensitive to light, protection from visible and UV light is necessary in sample preparation and analysis.
x		Vitamins can be oxidized very rapidly. Therefore, protection is necessary, e.g. addition of antioxidants or a rapid analysis after sample preparation.
x		Heating can lead to a vitamin isomerization and therefore losses.
	x	All analytical methods for vitamins capture all isomers, vitamers and those bound to other components.
x		Ideally, analysis of vitamins should be able to measure individual vitamers or components and their vitamin activity separately, if appropriate.
	x	The analysis of vitamins should capture interfering substances that have no vitamin activity.

For learners with advanced knowledge
IVd.Q16 For B vitamins, which methods have been developed in addition to the existing microbiological assays and colorimetric methods, and for which reason? *(2 points: 1 point for each correct response following (•))*

Answer (see Greenfield & Southgate, 2003, pp. 135-144):

(•) Ion exchange chromatography and HPLC have developed because they provide **(•)** a complete analysis, are rapid, and have reasonable precision. However, they do not necessarily capture all vitamers (e.g. folate).

For learners with advanced knowledge
IVd.Q17 Some analytical methods may be purpose-driven (targeted analysis vs. screening). Are the analytical methods for nutrients in foods, as recommended by Codex Alimentarius, always those used for food composition purposes? Select the correct statement. *(1 point)*

Note: See the Codex Alimentarius document available at:
http://www.codexalimentarius.net/download/standards/388/CXS_234e.pdf

Answer (see Greenfield & Southgate, 2003, p. 85):

True	False	Analytical method used in food composition are the same as those recommended by Codex
	x	Yes, because laboratories use the same analytical methods for several purposes.
x		No, because the methods recommended by Codex are mostly used to check products' conformity to current legislation. They do not always need to be as precise as those needed for food composition data.
	x	No, because food-quality control has higher requirements for analytical work than food composition programmes.

IVd.Q18 When analytical data are generated with a recommended analytical method, is the value always of good quality? Select True or False. *(1.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 91-96):

True	False	Quality of component value generated with a recommended analytical method
	x	All laboratories can perform the recommended analytical method and produced reliable, good-quality analytical data.
x		When the recommended analytical methods represent the determination step of the analytical procedure, then the separation, extraction, preparation and calculation steps (if applicable) should also be considered when evaluating the analytical value and its quality.
	x	Some laboratories modify the standard procedure of the recommended analytical method. These modifications do not need to be considered because they do not influence the value or its quality.

For your information:
A laboratory commissioned to carry out analytical work for food composition should always be able to demonstrate its ability to analyse specific components in the food matrix. If a laboratory is unable to provide proof of a good performance, the analytical results might not be of the desired quality and the money spent on the analytical work might be lost because the results cannot be used for food composition purposes. This might happen even if the analytical method is a recommended one for the component. More information on this issue is provided in module 6.

This question is about laboratory performance and should not be confused with method performance. Laboratory performance is an issue of quality of the analytical value, e.g. the value was validated by using Certified Reference Material (CRM), and is therefore applicable for all analytical results of the given component in a specific food matrix. Method performance establishes the performance characteristics and limitations of a method and identifies the influences which may change these characteristics and determines the extent of change.

IVd.Q19 Indicate the criteria that should be taken into account when validating the analytical method for a given food and component. Select True or False. *(2 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 91-96):

True	False	Criteria to validate an analytical method for a given food and component
x		Validation of the analytical method for a selected food matrix and component is done using the CRM for the specific food matrix and component concentration.
x		Validation of solvents, enzymes and columns are necessary, and of saponification and extraction steps, if appropriate.
x		Validation of the limit of detection and limit of quantification (LOD and LOQ) of the instrument and method should be carried out.
x		Validation is necessary if the method is fit-for-purpose, i.e., regulatory compliance vs. food composition; sufficience of total value only vs. also analysing contributing compounds.

SAMPLE ANSWERS TO THE EXERCISES[21]

For learners with advanced knowledge

IVd.E1 Complete the figure on the principles of measuring carbohydrates and dietary fibre using the following words: *(6.5 points: ½ point for each correct response)*

- ash
- protein
- nitrogen
- lipid components
- NSP
- lignin
- NSP - Englyst method
- Total dietary fibre - AOAC Prosky method
- free sugars
- glucose
- monosaccharides
- starch
- resistant starch

Answer (see Greenfield & Southgate, 2003, pp. 118-120):

Food sample (dried and finely divided, and defatted if high fat content)		
↓		
Extract with 80% v/v aqueous alcohol (extracts lipid components)	→	Use extract to measure free sugars
↓		
Hydrolyse starch enzymatically and precipitate NSP with 80% v/v alcohol	→	Measure glucose to estimate starch
↓		
Filter and wash residue (includes, ash, protein, NSP, resistant starch, lignin etc)	→	Hydrolyse with acid, measure component monosaccharides
↓		↓
Weigh residue		NSP – Englyst method
↓		
Measure ash and nitrogen		
↓		
Deduct from residue weight	→	Total dietary fibre - AOAC Prosky method

IVd.E2 Match the following tagnames to the inclusion of the different dietary fibre compounds: FIBC, FIBAD, FIBTS, FIBTG, PSACNS/NSP, FIBND. *(3 points: ½ point for each correct response)*

Note: See Greenfield & Southgate, 2003, p. 109 of Monro and Burlingame (1996), available at: http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%236879%231996%23999909997%23307729%23FLT%23&_cdi=6879&_pubType=J&_auth=y&_acct=C000055286&_version=1&_urlVersion=0&_userid=6718006&md5=5758f2861be3a2fcfda26c5c3bed752e or FAO (2003) p. 26 in PDF file at ftp://ftp.fao.org/docrep/fao/006/y5022e/y5022e00.pdf or Klensin *et al.* (1989) p. 84 in the PDF file.

[21] Individual correct answers may vary.

Answer:

Tagname	Lignin	Cellulose	Hemicellulose	Pectin	Non-pectin soluble	Resistant starch RS1|RS2|RS3|RS4	Non-specified
FIBTG	—	—	—	—	—	—	—
FIBTS	—	—	—	—	—	—	—
PSACNS /NSP		—	—	—	—	—	
FIBAD	—	—	—	—			
FIBND	—	—	—	—			
FIBC	—	—	—				

IVd.E3 A compiler commissioned a laboratory to analyse the fatty acid composition of ten foods. After two months, the compiler receives data for a food with the following values expressed in grams per 100 g fatty acids: 2 g F14:0; 5 g F15:2; 10 g F22:1. The compiler needs to express them in g per 100 g edible food in the food composition database. Formulate three questions that the complier should ask the laboratory. *(3 points: 1 point for each correct response)*

Answer:

The following three questions may be asked:
- What is the water content?
- Where are the other fatty acids data? The sum of the reported fatty acids is 17g/100g of fatty acid (=2+5+10), meaning that there are 83g fatty acids missing.
- What is the total fat content of the food? This value is required to calculate the fatty acid content in 100g edible portion from the values expressed per 100g fatty acids.

IVd.E4 In the following tables (macronutrient analysis, inorganic material analysis, vitamin analysis and analysis of other compounds), fill in the blanks marked in yellow. The recommended methods of analysis are marked by *. *(13 points: ½ point for each correct response)*

Abbreviations used:
AAS = Atomic absorption spectroscopy; **GLC** = Gas-liquid chromatography, also called gas chromatography (**GC**); **GLC-MS** = Gas-liquid chromatography coupled with mass spectrometry; **GSC** = Gas-solid chromatography; **HPLC** = High-performance (formerly high-pressure) liquid chromatography; **ICP-MS** = Inductively coupled plasma mass spectrometry (or plasma emission spectrometry) coupled with mass spectrometry; **ISE** = Ion-specific electrode; **LC-MS** = Liquid chromatography with mass spectrometry; **NIR** = Near infrared reflectance; **NMR** = Nuclear magnetic resonance

Note: The main aim of this exercise is to know where to find the analytical methods per components in Greenfield and Southgate (2003) and to have a comprehensive reference for limitations, applications and preferences of analytical methods according to current standards.

Answer (see Greenfield & Southgate, 2003, pp. 98, 100, 104, 108, 112, 114, 116, 122, 124, 126, 136, and 137):

Macronutrient analysis

Food component	Available method of analysis	Limitation	Application
Water (moisture)	Air oven*	Caramelization of sugars, degradation of unsaturated fat, loss of volatiles	This method is applicable to all foods at 60˚C. At 100˚C, it is applicable to all foods except those rich in fat and sugar
	Vacuum oven*	Loss of volatiles	
	Freeze-drying*	Slow. Care must be taken to avoid residual water in samples	Applicable to most foods
	Microwave oven	Charring	Applicable to medium- or high-moisture foods only
	Dean and Stark distillation	Safety of solvents used	Applicable to foods high in volatiles*
	Karl Fisher		Applicable to low-moisture, hygroscopic foods
	Physical methods (NMR, NIR)	High cost and needs calibration for each food group	NMR is applicable to most foods. NIR is only established for cereals and some other foods
	Chromatography (GLC, GSC)	High cost	GLC is applicable to meat and meat products only. GSC is applicable only to some meat products
Total fat	Continuous extraction (single solvent, also called Soxhlet)	Time consuming. Extracts cannot be used for fatty acid studies. Incomplete extraction from many foods (dry analytical samples). Non-comparable value for cereals	Applicable to low-moisture foods and non-cereal foods
	Acid hydrolysis	Some hydrolysis of lipids. Extracts cannot be used for fatty acid studies	Applicable to all foods except dairy and high-sugar products
	Acid hydrolysis and capillary GLC	High cost. This method is NLEA-compliant	Applicable for most foods
	Mixed solvent extraction *	Complete extraction from most foods. Extract often needs clean-up	Applicable to most foods and extract can be used for fatty acid analysis
	Alkaline hydrolysis		Validated for dairy foods only
	NIR	High cost. Requires extensive calibration against other methods	Established only for cereals
Fatty acids	HPLC	High cost	
	GLC *	Moderate to high cost	Applicable to all foods. If used for *trans* fatty acids, capillary techniques are required
	Infrared absorption (for trans fatty acids)	High cost. Some interference	Applicable to all foods

Polyols	Specific enzymatic method	Specificity of enzymes	Limited to a few polyols only
	HPLC*	Moderate to high cost. Lack of standardized procedures; choice of column	Can be applied to complex mixture
	Microbiology	Acyclic polyol only	All foods
Oligosaccharides	Specific enzymatic procedures	Moderate to high cost	Applied for selective hydrolysis and separation
	GLC	Moderate to high cost. Choice of column	Can be applied to complex mixture
	HPLC		Complex mixtures
Starch	Polarimetry	Needs very careful calibration	Applicable only to some cereal foods
	Dilute acid hydrolysis using a general sugar method	Interference from any NSP present.	Applicable to highly refined foods that are low in NSP
	Dilute acid hydrolysis and glucose-specific method	Presence of β-glucans	Applicable only to foods low in β-glucans
	Enzymatic hydrolysis and glucose specific method*	Choice of enzymes and conditions	Applicable to all foods
Dietary fibres			
Total dietary fibre	AOAC method for dietary fibres (Prosky *et al.*) * - a enzymatic–***gravimetric*** method	Time-consuming	Applicable to all foods
Non-starch polysaccharides (NSP)	Enzymatic hydrolysis and removal of starch. Acid hydrolysis of NSP, GLC, HPLC separation of component monosaccharides. Colorimetric analysis of monosaccharide (Englyst et al.)	Moderate to high cost. Resistant starch must be treated before hydrolysis. GLC requires preparation of derivatives. Gives only total values. This method is not robust	Applicable to all foods
Resistant starch	Enzymatic hydrolysis of starch before and after treatment with alkali or DMSO	Choice of enzymes and conditions	Applicable to all foods

* recommended method

Total nitrogen /protein	Kjeldahl (for total nitrogen) *	Minor interference from inorganic nitrogen. Toxic wastes	Applicable to all foods
	Dumas (for total nitrogen) *	Limitations are high cost, the inclusion of inorganic nitrogen and analytical portion size	Applicable to all foods
	Radiochemical methods (for total nitrogen)	Very high cost of instrumentation	Applicable to most foods
	Formol titration; Biuret; Folin's reagent (for protein)	Specificity	Applicable to dairy products only
	Alkaline distillation (for protein)	Specificity	Applicable to cereals only
	Dye-binding (for protein)	Specificity	Applicable only to specific foods, and some cereals and legumes
	NIR (for protein)	High cost. Number of calibration sample	Applicable to some foods
Amino acids (AA)	GLC (preceded by acid hydrolysis for most AA. Alkaline hydrolysis required for tryptophan. Special hydrolysis conditions required for sulphur AA and acid-sensitive AA.)	Moderate to high cost. Choice of derivative is critical. AA need to be derivatized prior to chromatography	Applicable to most foods
	HPLC* (Preceded by acid hydrolysis for most AA. Alkaline hydrolysis required for tryptophan. Special hydrolysis conditions required for sulphur AA and acid-sensitive AA. AA usually derivatized prior to chromatography)	High cost	Applicable to all foods
	Ion-exchange chromatography* (Preceded by acid hydrolysis for most AA. Alkaline hydrolysis required for tryptophan. Special hydrolysis conditions required for sulphur AA and acid-sensitive AA.)	High cost. Hydrolytic losses of more labile AAs and slow release of branched chain AAs	Applicable to all foods
	LC-MS	High cost	Applicable to all foods
	Colorimetry (Tryptophan and S containing AA, lysine)	Not sensitive enough	Applicable to all foods
	Microbiological assays	Tedious, time-consuming, non reproducibility	Applicable to all foods
Alcohol	Distillation*	Interference with volatiles	Applicable to all foods
	GLC*		Applicable to all foods
	Specific enzyme method*		Applicable to all foods
Sugars, total (mono and disaccharides)	Density	Accurate for sucrose	Applicable to sugar solutions
	Refractive index	Empirical calibration required	Applicable to sugar solution
	Polarimetry	Close attention to standardized methods is essential	Applicable to single sugars or simple mixture only
	Reductiometric	Non-reducing sugars, sucrose and invert sugar mixtures	Applicable to reducing sugars
	Colorimetric	Specificity	Applicable to single sugars and simple mixtures
	Specific enzyme method *	Reagents can be expensive	Applicable to glucose and complex mixtures
	GLC	Need for derivatives	Can be applied to complex mixture
	HPLC *	Moderate to high cost. Choice of columns, detectors are crucial	Can be applied to complex mixture

Vitamin analysis – applicable to all foods

Food component	Available method of analysis	Limitations
Retinol	Colorimetry	Obsolete (Carr and Price, 1926). Low recoveries of retinoids
	HPLC *	Moderate to high cost. Identification of carotenoids
Carotenoids	Open column chromatography	Identification of carotenoids. Lack of resolution of some geometrical isomers (lutein/zeaxanthin) and stereo-isomers (cis/trans).
	HPLC *	Moderate to high cost. Identification of carotenoids
Vitamin D	Bioassay	For low level only; animal facilities required
	Colorimetry	Lack of precision and sensitivity
	Gas-liquid chromatography (GLC)	New procedures under development
	HPLC*	High cost. Lipid interference; two stages, preparative followed by analytical separation needed for most foods
	Radio-immunoassay	High cost
Vitamin E	Colorimetry	Interfering compounds
	GLC	Derivation prior to chromatography required
	HPLC *	High cost. Extraction techniques
Vitamin K	Colorimetry	Lack of specificity
	Column chromatography, GC*	Moderate to high cost for GC
	HPLC*	High cost. Lipid interference
Vitamin C	Dye titration	Measure ascorbic acid only; pigments interfere; value lower as HPLC but comparable values for fresh fruits and vegetables
	Colorimetry	Measures inactive compounds also
	Fluorometry	Does not separate ascorbic and dehydroascorbic acid
	GLC	Derivitization prior to chromatography required
	HPLC *	High cost. Clean-up and separate detection of homologues add delays
Thiamin/ Riboflavin	Microbiological*	Time
	Fluorometry	
	HPLC*	High cost
Niacin	Microbiological*	Time
	Colorimetry	Hazardous reagent
	HPLC*	High cost.
Vitamin B6	Microbiological*	Time; response to different vitamers may not be equal; total values only
	HPLC*	High cost
	Radiometric-microbiological	High cost
Vitamin B12	Microbiological*	
	Radio-isotopic	High cost
Folates	Microbiological *	Response to different vitamers may not be equal; total values only
	HPLC	High cost. Not all vitamers measured properly
	LC-MS	Very high cost, but this method is able to quantify the different isomers of folates
Pantothenic acid	Microbiological*	
	HPLC	High cost
Biotin	Microbiological*	
	Isotope dilution	High cost
	Radiometric-microbiological	High cost
	Radio-immunoassay	High cost
	Protein-binding	High cost
	HPLC	High cost

* recommended method

Inorganic material analysis - Applicable to all foods after defatting and drying, especially for food high in fat and/or water content

Food component	Available method of analysis	Limitations
Total Ash	Dry ashing	Not suitable for mineral analysis of volatile minerals because of their partial loss
	Wet ashing	Small sample throughput
Cations		
Na*, K*, Ca, Mg	Flame photometry	Interference
Na, K, Ca*, Mg*, Fe*, Cu*, Zn*, Mn*, Co*, Cr*	Atomic Absorption Spectrometry (AAS) with electrothermal furnace	Moderate to high cost. Interferences from anions; special suppression techniques
Se*	Hydride generation AAS	Moderate to high cost
	Fluorimetry	
all cations	Plasma emission spectrometry (= inductively coupled plasma spectroscopy ICP) ideally coupled with Mass spectrometry (MS)*	Very high cost. Matrix effects need to be controlled
K, Mg, Fe, Cu, Zn	Colorimetry	Extracting techniques. Difficult for K and Zn
Ca and Mg	Classical precipitation and titration	Size of analytical sample; skilled techniques
Anions		
Phosphorus	Colorimetry	
	ICP-MS	Very expensive
Chloride	Titrimetric	
	Ion-specific electrode (ISE)	Interference
	ICP-MS	Very expensive
	Automated conductimetry	High cost
Iodine	Microdistillation	Laboratory contamination
	ISE	
	ICP-MS	Very expensive
	Alkaline dry-ashing	
	GLC	High cost
Fluorine	Microdistillation	Time-consuming
	Ion-specific electrode (ISE)	
	Polarography	
Sulphur	Gravimetric	
	X-ray fluorescence	High cost
	ICP-MS	Very expensive
Nitrite	Colorimetry	
	Ion-specific electrode (ISE)	
Nitrate	HPLC	High cost

Analysis of other components

Food component	Available method of analysis	Limitations
Hemagglutinins/Lectins	RBC agglutination	Not all blood samples of one animal species will react in an identical manner owing to the existence of several blood groups. Agglutination dilution test semi-quantitative
	Spectrophotometric methods	
	Radioactive labelling of lectin molecules	Requires specialized handling
Phytic acid	Anion exchange	Inability to resolve inositol phosphates adequately
	HPLC	High cost
	GLC	Detects derivatize volatile inositol phosphate forms only after separation by ion-exchange chromatography
	Capillary electrophoresis	Not applicable to all foods
	NMR-MS	High costs. Specialized application
Oxalates	Capillary electrophoresis	Not good for low oxalate content <1.8 mg/100 g. Meant for routine monitoring
	Ion chromatography	High running cost
	GLC	Some forms of oxalate are difficult to methylate; high instrument cost
	Enzymatic	Not applicable to all foods
	Colorimetry (AOAC)	Interference from other acids
	HPLC	High cost
Tannins (grouped into condensed tannins also called proanthocyanidins, hydrolysable and derived tannins)	UV-Spectrometry Vanillin HCL reagent	Parameters like extraction time, temperature, vanillin and HCL concentration need to be strictly controlled
	UV-Spectrometry Folin-Denis reagent	Non-specific as they can react with any phenol present in plant tissue
	UV-Spectrometry Prussian blue reagent	Non-specific as they can react with any phenol present in plant tissue, qualitative test
	HPLC	Modest success for smaller compounds of derived tannins
	Colorimetry	Limited to basic compounds of hydrolysable tannins
Saponins	Spectrophotometric method	Not suitable for determination of medicagenic acid for which titrimetric method for the quantitative determination of this aglycone content has to be employed
	Bioassays	
	HPLC	Identification of individual saponins
Trypsin inhibitor	Colorimetric	Does not differentiate between the different protease inhibitors
	ELISA method using monoclonal antibodies derived from mice	
Flavonoids	HPLC	Sample hydrolysis required for optimum resolution and quantisation of quercetin, kaempferol, myricetin, luteolin and apigenin. Separate extraction without hydrolysis required for analysis of anthocyanidins and flavan-3-ols
	LC-MS	Hydrolysis not required as long as masses of individual flavonoid conjugates differ by more than mass resolution of mass spectrometer
Isoflavones[1] and coumestrol	HPLC	Complex conjugates, and their numbers may be difficult to resolve with some reversed-phase columns and simple mobile-phase programs (isocratic)
	LC-MS	Hydrolysis not required as long as masses of individual flavonoid conjugates differ by more than mass resolution of mass spectrometer
Lignans	HPLC	Isolariciresinol, pinoresinol, secoisolariciresinol and matairesinol
	GLC-MS	Only for matairesinol, secoisolariciresinol and shonanin in foods as trimethylsylyl derivatives

[1] Isoflavones are a subclass of flavonoids but because they have different and unique biological activities than other subclasses of flavonoids, they are analysed and compiled as a separate group

GENERAL FEEDBACK USING SELF-SCORING

Analysts and laboratory workers should achieve the first two categories, whereas it is sufficient for compilers and professional users to achieve the last three.

91 – 113.5 points: You have very well understood and integrated issues on methods of analysing components. Congratulations. You are well prepared to apply the issues in your work.

61 – 90 points: If you are an analyst, you have understood and integrated most issues on methods of analysing components. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so before being able to apply the new knowledge in your work. If you are a compiler or professional user, the knowledge you have acquired is excellent for your purpose.

31 – 60 points: If you are an analyst, you have understood and integrated a fair part of the issues on methods of analysing components. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so before being able to apply the new knowledge. If you are a compiler or professional user, the knowledge you have acquired might well be enough for your purpose.

0 – 30 points: If you are an analyst, you appear to have significant gaps in your understanding of issues on methods of analysing components. You should read the sections again and improve your knowledge of these topics before being able to effectively apply the new knowledge. If you are a compiler or professional user, the knowledge you have acquired might be sufficient for your purpose.

Module 5

SAMPLING

LEARNING OBJECTIVES

By the end of this module the student will:

- understand the principles of sampling, sampling protocols, sample collection and transportation, sample handling in the laboratory and documentation,
- understand specific sampling aspects for food biodiversity purposes;
- be aware of potential errors in nutrient values caused by incorrect sampling;
- grasp the importance of sampling as a data-quality issue;
- be able to develop a simple sampling plan.

REQUIRED READING

- **Annor, G. A.** Sampling of food for analysis. PowerPoint Presentation. Available at: http://www.fao.org/infoods/presentations_en.stm
- **Annor, G. A.** Sample collection, handling and preparation. PowerPoint Presentation. Available at: http://www.fao.org/infoods/presentations_en.stm
- **Charrondière, U.R**. 'Sampling', available at: http://www.fao.org/infoods/presentations_en.stm

and if possible:

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use*. FAO. Rome. Chapters 1 (pp. 26–28[22]) and 5 (pp. 63–82), and appendices 2 (pp. 214–215) and 3 (pp. 216–220). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf

SUGGESTED ADDITIONAL READING

- **Codex Alimentarius**. 2004. *General Guidelines on Sampling*. CAC/GL 50. pp.8-29. Available at: http://www.codexalimentarius.net/web/standard_list.do?lang=en;

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers +++++
- Professional users +
- Analysts +++++

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1–3 hours
- Answering the questions: 1–3 hours
- Completing the exercises: 1–3 hours

[22] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to the PDF file.

Answers to the questions

V.Q1 What is the purpose of sampling within a food composition context? Select True or False. *(2.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 63):

Objectives of sampling	True	False
To identify the one food sample to represent the entire food supply		x
To collect representative samples of foods in the food supply	x	
To compare different diets in different countries		x
To generate comprehensive and representative compositional data for specific foods	x	
To show the variability of nutrient values in foods	x	

V.Q2 From the following list, indicate the characteristics of a food that contribute to variability in nutrient composition. Select True or False. *(5.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 69-71):

Characteristics contributing to variability in nutrient composition	True	False
Geography and season	x	
Part of the food	x	
Maturity	x	
Package size		x
Cultivar, variety and breed	x	
Brand names	x	
Batches	x	
Fortification level	x	
Colour	x	
Fat and water content	x	
Preparation and processing method	x	

For your information:
Significant differences in the water and fat content or in preparation or processing indicate that the foods are different. Therefore, these factors must be taken into account when sampling and in selecting foods for inclusion in the food composition tables and databases, analysis and documentation.

V.Q3 Match the food sampling terms to the correct definitions. *(6 points: ½ point for each correct response)*

Note: It may be helpful also to consult the Codex document CAC/GL 50 pp. 8-29; available at: http://www.codexalimentarius.net/web/standard_list.do?lang=en.

Terms:
1. Stratified sampling
2. Random sampling
3. Primary food sample
4. Composite food sample
5. Unit
6. Analytical portion
7. Laboratory sample
8. Convenience sampling
9. Reduced food sample
10. Analytical sample
11. Selective sampling
12. Batch/lot

Answer (see also Greenfield & Southgate, 2003, pp. 64, 71 and 73; and CAC/GL 50 pp. 8-29):

Term	Definition
8	Samples are taken on the basis of accessibility, expediency, cost or other factors not directly concerned with sampling parameters.
2	Samples are taken in such a way that any one unit has an equal chance of being included.
11	Samples are taken in accordance with a sampling plan that excludes material with certain characteristics or selects only those with clearly defined characteristics.
6	The quantity of food of the correct size for each analytical measurement.
4	The sample is produced by mixing the primary samples (items) before analysis. This represents a loss of information on sample-to-sample variations.
10	The portion prepared from the samples stored in the laboratory, from which further portions are taken for analysis.
1	Units of sampling are taken from defined strata of the parent population. Samples are taken at random within each stratum or division.
7	Samples sent to or received by the laboratory.
5	It is a discrete, identifiable food that is suitable for removal from the population as a sample and that can be individually described, analysed or combined.
12	It is a quantity of a commodity manufactured or produced under conditions presumed to be uniform.
3	The unit(s) collected during the first stage of the sampling.
9	It is a representative part of the primary sample.

V.Q4 Which of the following sampling methods is recommended for use in food composition programmes? Select the correct method. *(1 point)*

Answer (see Greenfield & Southgate, 2003, pp. 70-71):

	Sampling methods
	Selective sampling is preferred because it follows a precise sampling plan.
	Random sampling is preferred because it ensures that any one unit has an equal chance of being included.
x	Stratified sampling is preferred because the population of food is classified into strata, and samples are selected at random in each strata. Account is also taken of the most important causes of variation.
	Convenience sampling is preferred for all foods because it may be the only practical way of sampling wild or uncultivated foods.

V.Q5 Food sampling may be based on different principles according to: (1) the demographics of the population that consumes the food (i.e. population-based approach), (2) where the foods are produced, or (3) a mixture of both. Select the explanation that corresponds to the population-based approach. *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 66):

	Population-based sampling plan
	It takes account of the distribution of the food population within the study area.
x	It takes account of the human population density and distribution.
	It presumes that the foods are not distributed equally.

For your information:
With the population-based approach, it is presumed that the density of the population is equal to the density of foods consumed; therefore, food sampling may be based on the distribution of the population in the country concerned. It presumes that the foods available in the area are consumed in the area, except for brand name foods produced in a few factories and distributed nationwide. This is not a recommended approach for food biodiversity sampling.

V.Q6 In general, the sampling protocol is developed by the compiler and describes all stages, from the collection of food samples to their transportation to the laboratory. The analytical protocol is developed by the analyst and describes all stages, starting from arrival of the food samples in the laboratory up to the reporting of analytical data. Transportation of samples and the preparation of the composite food sample may be part of the sampling or analytical protocol. In the table, match the statements below to A (sampling protocol) or B (analytical protocol). Note that some statements may correspond to both protocols. *(10.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 74-81):

A Sampling protocol **B Analytical protocol**

	Information
A	It is based on general knowledge of the foods, e.g. food group, seasonal availability, market share.
A	It is based on information on how foods are produced, processed, distributed and consumed.
B	It describes laboratory equipment and facilities.
B, A	It describes procedures to process food samples.
A	It describes how many units of foods are to be collected.
A (B)	It describes how food samples are transported from collection sites to the laboratory.
B	It describes storage conditions at the laboratory.
B	It describes the laboratory staff.
A	It describes possible sites for sample collection.
B	It describes methods for analysing nutrients.
A	It describes measures for ensuring the personal security of samplers.
A	It describes the appropriate division of sampling areas into sampling units.
A	It describes procedures for storing food samples prior to being sent to the laboratory.
A (B)	It describes the time schedule for transporting the food samples from collection sites to the laboratory.
A	It describes how long the food samples are stored before being sent to the laboratory.
A	It describes how the samplers are paid.
B	It describes how long laboratory samples are stored.
B	describes the laboratory's quality assurance and quality control system.
B	It lists the nutrients to be analysed, including water.
A, B	It describes training activities.
A, B	It includes budget allocations.

For your information:
Even though description of analytical methods is part of the analytical protocol, the decision on the analytical method is taken together with the compiler.

V.Q7 Indicate the reasons for compilers and analysts to collaborate in the development and implementation of the sampling and analytical protocol. Select True or False. *(3 points: ½ point each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 26-28):

Why compilers and analysts should collaborate in developing and implementing the sampling and analytical programme	True	False
To benefit from integrated planning and budgeting (e.g. to estimate required resources) because sampling and analysis are linked to each other	x	
To ensure better method performance		x
To ensure better data quality, representativeness and documentation	x	
To ensure that sampling sites are close to the laboratory		x
To ensure a smooth process, from sampling to analysis (e.g. effective sample transportation and sample handling; proper sample storage time/capacity/temperature)	x	
To ensure that sampling and analyses are carried out in a way so that similar foods or foods of the same food groups are collected and analysed at the same time. This facilitates analysis because of their similar food matrix and concentrations (i.e. easier for calibration, reference material, etc)	x	

For your information:
If the sampling and/or chemical analysis is assigned to a contractor, the latter must be aware of expected (and required) quality standards, as well as of planned logistics and time schedules.

V.Q8 Indicate the characteristics of a good sampling plan/frame/protocol. Select True or False. *(5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 63-64, 72-75):

Characteristics of a good sampling plan/frame/protocol:	True	False
provides a detailed description of the sampling process to be undertaken.	x	
is a precise, well-documented protocol written after completion of the sampling process.		x
describes the sampling type and its particular design.	x	
is written with the objective of ensuring that no significant changes in composition occur between collection and analysis.	x	
lists several possible sampling methods per food sample, leaving the final choice to the sample collector.		x
defines the number and size of samples.	x	
is always written under contract.		x
is based on a clear understanding of the food populations studied.	x	
describes any changes in food composition between collection and analysis.		x
defines the sampling sites.	x	

V.Q9 Match the following expressions to the corresponding description. *(1.5 points: ½ point for each correct response)*

Expressions:
1. Number of food samples collected
2. Number of analytical samples (sample size)
3. Number of replicates

Answer (see Greenfield & Southgate, 2003, pp. 73-74):

Expression	Description
2	The number of food samples analysed. A food sample may contain several foods collected at different sample sites and in different seasons. This number is reported as the number of samples in food composition tables (i.e. 'n').
3	The number of analytical repetitions of the same analytical sample to estimate the analytical variability of the method. Analyses made in duplicate means that the same analytical sample was analysed twice; analyses made in triplicate means that the same analytical sample was analysed three times. This number is reported separately and is not indicative of the number of food samples involved.
1	The number of food units initially taken from the total food population.

For your information:
In many cases, several sampled foods are combined into one composite food sample. This makes it possible to reduce the number of food samples analysed, but it reduces indications of variability in nutrient values. If multiple samples of the same food are analysed individually, information on the variability within a given food is provided (between varieties or different brands of the same processed food).

V.Q10 What is the formula for calculating an adequate sample size, taking account of possible variations of nutrients in the food and of expected accuracy? *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 214):

sample size > $(t_{\alpha\, n\text{-}1})^2$ x SD^2/ (accuracy X mean)^2

For your information:
where
t value is taken from standard statistic tables of the student's *t* table
α defines the confidence limit. α = 0.05 for 95% confidence
n = sample size
n – 1 the degree of freedom
SD = standard derivation of the sample mean

For your information:
This is a theoretical calculation and often, not all elements are known to calculate the sample size in this way. Therefore, other approaches are taken, such as rules of thumb or case-by-case considerations depending on the food and the purpose.

V.Q11 As a rule of thumb, how many foods should be composited into one food sample in general, and for United States' labelling legislation in particular? What should be the minimum number of analytical samples per food, especially if the results are to be published in peer reviewed journals? *(1.5 points: ½ point for each correct response following the dot (•))*

Answer (see Greenfield & Southgate, 2003, p.74):

In general, it is accepted that **(•)** 10 foods are collected and put together into one analytical sample. The United States demands **(•)** that 12 foods be collected per food for labelling purposes. If analytical results are to be published, most scientific journals require **(•)** a minimum of three analytical (independent) samples per food (and two-to-three replicates per sample).

For your information:
It is even better to analyse five (or more) independent samples as that adds weight to the data and increases their quality.

V.Q12 **It may become necessary to reduce the budget during the course of writing the combined protocol, i.e. combination of sampling and analytical protocol. If the intension is to publish the results in the scientific literature, which options should be chosen? Select the correct reply.** *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 81):

	Options for reducing costs
	Reduce the number of samples to one composited analytical sample per food
	Reduce the number of foods per analytical sample from 10 or 12 to three
x	Reduce the number of analytical samples to three per food

For your information:
A minimum of three analytical (independent) samples (i.e. n = 3) are needed to calculate a meaningful average and standard deviation (SD), and to publish analytical results in the scientific literature. Many more samples are needed to study different variables (e.g. varieties, agricultural practices, or soil).

V.Q13 **Determine the correct order of the different sampling stages, from the acquisition of samples to their analysis. Assign a number to each step, where 1 is the first step and 6 the last.** *(3 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 65, figure 5.1):

Sampling operations	Order
Analyse the component(s)	6
Create composite samples	3
Take samples from bulk or packaged goods by selecting one or several batch(es) or lots	1
Take primary/gross samples	2
Prepare laboratory samples	4
Prepare test samples and portions	5

V.Q14 **What type of information should appear on the following food labels or records? Match the numbers of the corresponding food descriptions to the types of labels. Note that multiple answers are possible.** *(5 points: 1 point for each correct response)*

	Food description on label
1	Weight and nature of inedible matter; weight and nature of edible matter; weight before cooking; weight after cooking; method used to take analytical sample; storage of food sample and of analytical sample; date of receipt in laboratory.
2	Alternative names; scientific name; state of maturity; grade; plant or animal food
3	Local use of food; physical dimensions; physical state; process and preservation method; batch number; packing medium
4	Common name of food; sample code number
5	Date and time of collection; name of collector; place of origin; sampling point; season; transportation conditions

Answer (see Greenfield & Southgate, 2003, pp. 75-78):

Type of label or record	Food description on label
Label on food sample	4
Record of food identification	2, 4
Record of collection	5, 4
Record of description of samples collected	3, 4
Record of handling in laboratory	1, 4

V.Q15 **Indicate the steps to prepare the following foods for analysis. Use the numbers in the table of sample preparation steps and try to indicate them in the correct order. See the example for bread.** *(5 points: 1 point for each correct response)*

	Sample preparation steps
1	Quarter
2	Dry
3	Mill or grind with pestle and mortar
4	Mix
5	Homogenize
6	Clean
7	Separate different parts
8	Separate edible portion
9	Chop
10	Freeze and crush
11	Mince
12	Avoid separation during mixing
13	Use electric mixer or grinder

Answer (see Greenfield & Southgate, 2003, pp. 216-220):

	Sample preparation steps
Example: bread	**1, 2, 3, 4**
Flour or dried milk or sugar	4, 1
Meat and fish	6, 7, 8, (9), (10 for inorganic analysis), 11, 4 (12), 5
Biphasic sauces	4, 12, 5
Pineapple	6, 8, 1, 9, 13, 5
Cabbage	6, 8, 1, 9, 13, 5

For your information:
The homogenization step is not always mentioned in Greenfield and Southgate (2003) but is listed here because it is used frequently.

V.Q16 **Indicate, from the following examples, whether the analysed nutrient values are higher, lower or randomly different when one of the following errors occurs during sampling or sample preparation.** *(4.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 78-80):

	Lower nutrient value	Higher nutrient value	Randomly different value
Fatty acid content of margarine that was exposed to air during transportation	x		
Loss of water/moisture during storage		x	
Trace element content in food sample prepared in dusty environment		x	
Calcium content in fish when bones are discarded but eaten by the population	x		
β-carotene content in leeks when green leaves are included but are not eaten by the population		x	
Iron content of food prepared in blender with iron blades		x	
Improper mixing, cutting, mincing or grinding of the food sample			x
Exposure to light of light-sensitive vitamins	x		
Vitamin content in food sample that has not been properly homogenized			x

V.Q17 Storage time and conditions may have harmful effects on analytical samples. Match each possible effect of storage to the corresponding preventive measure(s) by using the numbers 1-7 in the table of precautions. Please note that multiple choices are possible. *(3.5 points: ½ point for correct responses per line)*

	Precautions
1	Store at low temperatures
2	Store samples in sealed or covered containers
3	Protect from light
4	Neutralize acid
5	Store at -30ºC in sealed containers under nitrogen. Addition of antioxidants or bacteriostatic agents
6	Pasteurization or addition of inhibitors
7	Gentle mixing and defreezing only once before analysis. Prepare the number of analytical portions needed for all analyses before storage

Answer (see Greenfield & Southgate, 2003, p. 80)

Storage effects	Corresponding preventive measure
Loss or gain of water	2
Microbial activity leading to losses of carbohydrates and protein but gains of vitamins B_1 and B_6	1, 6 (5)
Oxidation of unsaturated fatty acids	5 (3)
Acid hydrolysis, leading to losses of sugars and oligosaccharides	1, 4
Photodegradation of nutrients (e.g. riboflavin)	3
Separation of emulsions	7
Enzymatic activities leading to losses of sugar and vitamins	1, (6)

V.Q18 Which precautions should be taken when analysing foods for their vitamin C content? Select the correct response. *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 218):

True	Precautions for vitamin C analysis in foods
x	Rapid preparation and immediate analysis, ideally at 4°C
	Precautions for preparation and analysis are the same as for other nutrients
	Preparation in a dry environment and rapid analysis

V.Q19 Water analysis should be part of the sampling and analytical plan. When and why should water be analysed? Select True or False. *(2 points: ½ point for each correct response)*

Answer:

Statements concerning water analysis	True	False
Water should be analysed only after drying the food samples.		x
Water should be analysed before drying and storing the food samples.	x	
Water is needed to calculate nutrient values from dry-matter basis to fresh food weight.	x	
Water should be analysed once the foods are prepared for storage, e.g. dried, frozen or freeze-dried.		x

V.Q20 In the scientific literature, an article is found with nutrient values for a food that the compiler would like to incorporate into the national food composition database. The food is collected in a foreign country, and the sampling plan is very comprehensive and well done. The food was analysed with adequate analytical methods. Can the nutrient values in the article be considered as representing the food supply of one's own country and therefore be considered high quality score for sampling? Select the correct response. *(1 point)*

Answer:

True	Foods from different countries can represent foods of one's own country
	Yes, if the sampling plan is very comprehensive and the food name is the same. Their nutrient values should obtain a high quality score for sampling.
	Yes, if the sampling plan is very comprehensive and the sampling method would be similar in one's own country. The nutrient values should obtain a high quality score for sampling.
x	No, because the food is collected in a different country and many factors may be different among countries such as food varieties, soil, climate, processing or market shares. The nutrient values should obtain a low quality score for sampling.

Optional question for those with advanced knowledge or who have participated in a food composition course

V.Q21 Mangoes will be sampled in two seasons (December and May). For reasons of economy, a composite sample of the two seasons will be prepared before analysis for 10 nutrients, including vitamins (but excluding vitamin C). How should the first-season mangoes be stored? Select True or False. *(2.5 points: 1 point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 79-81):

Correct storage	True	False
At room temperature		x
In a refrigerator		x
In a deep freezer at -18°C		x
In a deep freezer at -30°C	x	
Freeze-dried	x	

<u>For your information</u>:
Foods should be stored at -30°C. Storage at -18°C might change the composition of foods.

Optional question for those with advanced knowledge or who have participated in a food composition course

V.Q22 A cheese is sampled and needs to be sent to a laboratory for vitamin analysis. Shipment to the laboratory takes three days. It is not possible to keep the sample cool during transportation and the ambient temperature is 35ºC. Select True or False. *(2.5 points: ½ point for each correct response)*

Answer:

Transportation considerations	True	False
Transportation in a sealed, isolating container with packed ice assures that the water and vitamin content will not be changed.		x
Transportation in a vacuum-sealed container with packed ice assures that the water and vitamin content will not be changed.		x
Transportation in a sealed, isolating container with liquid nitrogen assures that the water and vitamin content will not be changed.	x	
Any means of transportation may be chosen as long as it ensures that the vitamin content remains unchanged while the water/moisture content may change.		x
Another good laboratory that can be reached within 24 hours should be identified because transporting the cheese for 24 hours in an isolating container with packed ice will preserve its water and vitamin content for this period. Thereafter, the ice melts and changes in the cheese might occur.	x	

Optional question for those with advanced knowledge in food biodiversity

V.Q23 Sampling of foods also plays an important part in food biodiversity studies. What are the additional objectives of sampling when referring to food biodiversity ? Select True or False. *(2 points: ½ point for each correct response)*

Answer:

Considerations for food biodiversity studies	True	False
Establish connections between genetic resources and the nutrient composition of food	x	
Report connections between food composition and different brand name foods		x
Provide evidence of interactions between environmental influences and the composition of foods	x	
Provide representative year-round, nationwide, mean values for all foods		x

Optional question for those with advanced knowledge in food biodiversity

V.Q24 What additional information is needed to correctly identify foods for food biodiversity (i.e. on the level of variety, cultivar or breed) and to adapt the sampling plan for food biodiversity purposes? Select True or False. *(3.5 points: ½ point for each correct response)*

Answer:

Additional information needed for food biodiversity	True	False
For all foods, taxonomic information is needed at species level only.		x
Taxonomic information is needed on the level of variety, cultivar or breed.	x	
Genetic identification is desirable if taxonomic identification is not possible.	x	
Brand name information is needed.		x
Environmental and ecological information is needed.	x	
Food consumption frequencies are needed of the most frequently consumed foods (e.g. apples, tomatoes).		x
Information is needed whether ethical approvals are required when working with specific indigenous communities and/or protected species.	x	

Optional question for those with advanced knowledge or who have participated in a food composition course

V.Q25 Sampling for recipes is more complex than sampling for primary foods, and most sampling procedures do not cover recipes. Which data are necessary to develop a good sampling plan for recipes? Select True or False. *(4 points: ½ point for each correct response)*

Answer:

Additional data needed for recipes	True	False
The recipe should be representative of that consumed by the population and the amount of all ingredients for a homemade recipe should be known.	x	
The way a recipe is prepared in the country should be considered.	x	
A recipe prepared by a randomly-selected housewife with ingredients available in her home will be representative of how that recipe is prepared in the country.		x
In the case of a commercially prepared recipe (e.g. in a restaurant), it is not always possible to know which ingredients have been used or their quantities. At least 10 versions of the same recipe should be collected from different locations in order to represent the recipe. As this type of recipe may be very different to one prepared at home, it should be described as a commercial recipe.	x	
The sampling of ingredients for a recipe can be simplified (e.g. at a nearby market) because the most important consideration is that the amounts of ingredients are representative of the mean consumption of the recipe in the country.		x
Information about the recipes most often consumed in the country, and their ingredients, can be gathered from food consumption surveys and standard recipe books, or through focus groups.	x	
Ideally, sampling of ingredients for recipes should follow the same procedures as if they were collected for simple foods.	x	
The prepared recipe should be analysed as quickly as possible, or stored adequately to avoid compositional changes, especially of vitamins.	x	

For your information:
The recipes, with their ingredients and amounts thereof, should also appear in the user food composition table or database. The analysed recipe (e.g. prepared by a professional cook in accordance with the compiler's instructions) should be representative of its preparation in the country and all sampling steps, including of all ingredients, should be documented in the reference database. It might however be more cost-effective to analyse the ingredients and calculate the recipe (see module 8 for more information).

SAMPLE ANSWERS TO THE EXERCISES[23]

V.E1 A compiler intends to sample rice, the most important food in the country, and to analyse most nutrients for inclusion in the national food composition table. The country has a population of 60 million, 50 % of which lives in three equally important cities A, B and C. Cities A and B are situated in the north, and city C in the south. The rest of the population is equally distributed in 10 districts across the country. Half the rice is imported (one variety of white rice, and all parboiled rice) and the other half is grown in the country (two thirds in the North and one third in the South). There are two growing seasons in the North and one in the South. There are three varieties of rice: varieties 1 and 2 are grown in the North, and variety 3 in the South. Consumers are able to distinguish between the varieties of rice. Most is eaten as white rice, but 20% of the population eats parboiled rice. The predominant cooking method is boiling, but 10% fry it after boiling. There are no national food composition data available on rice. In a foreign food composition table, there are nutrient values for white and parboiled rice. Some examples:

	White rice, raw	Brown rice, raw
Protein (g)	8.4 (8.3-8.5)	9.0 (8.6-9.5)
Thiamin (mg)	0.41 (0.32-0.53)	0.59 (0.42-0.69)
Iron (mg)	0.5 (0.1-1.3)	1.4 (0.35-2.5)

Answers:

(a) The compiler wishes to analyse raw white rice as it is the food most widely consumed. Large differences are thought to exist in nutrient values between regions but much less so between seasons. The available budget allows analysis of three analytical samples of three foods. List the names of the foods to be analysed taking account of the origin of the rice. *(3 points: 1 point for each correct response)*

Name the three foods to be analysed for which differences are thought to exist due to the location of the rice production (region, imported)

1. Rice, white, Northern region, raw
2. Rice, white, Southern region, raw
3. Rice, white, imported, raw

For your information:
The analytical samples of the three foods could be:

- of 'Rice, white, Northern region, raw': analytical samples of city A, city B and one rural sample from any district. Each sample could be a composite of the two varieties.
- of 'Rice, white, Southern region, raw': two analytical samples of city C and one rural sample from any district
- of 'Rice, white, imported, raw': analytical samples from three different countries (bulk sample at the entry to the country) or three brands of imported rice.

(b) The compiler wishes to analyse raw white rice as it is the food most widely consumed. Large differences are thought to exist in the nutrient values of the national rice between seasons but much less so between regions. The available budget allows analysis of three analytical samples of three foods. List the names of the foods to be analysed taking account of seasonal differences, including for the imported rice. *(3 points: 1 point for each correct response)*

[23] Individual correct answers may vary.

Name the three foods to be analysed, if seasonal differences are thought to exist, including imported rice

1. Rice, white, season 1, raw
2. Rice, white, season 2, raw
3. Rice, white, imported, raw

For your information:
The analytical samples of the three foods could be:

- of 'Rice, white, season 1, raw': analytical samples of season 1 taken in each in city A, B and C
- of 'Rice, white, season 2, raw': analytical samples of season 2 taken in each in city A and B and one rural sample from any district (only one growing season in the South)
- of 'Rice, white, imported, raw': analytical samples of imported rice in three points in time (bulk sample at the entry to the country)

(c) The compiler wishes to analyse the nutrient content of variety 1. Large differences are thought to exist in nutrient values between locations but much less so between seasons. The available budget allows analysis of three analytical samples. List the names of the analytical samples considering the regional differences of variety 1. *(3 points: 1 point for each correct response)*

Food names of the three analytical samples of variety 1 if regional differences are suspected

1. Rice, white, variety 1, Northern province 1, raw (collected from 10 fields in this province)
2. Rice, white, variety 1, Northern province 2, raw (collected from 10 fields in this province)
3. Rice, white, variety 1, Southern province, raw (collected from 10 fields in this province)

For your information:
It is also correct to use the population-based approach, even though less useful in detecting differences in varieties due to regional differences as differences in varieties may be best detected when taking samples from where they are grown, i.e. from the field.

1. Rice, white, variety 1, city A, raw
2. Rice, white, variety 1, city B, raw
3. Rice, white, variety 1, city C, raw

(d) After having analysed the raw white rice for regional differences, an additional budget becomes available for three food analyses to investigate the nutrient content of cooked rice and to publish the results in the food composition database and in a scientific article. Select the correct response. *(1 point)*

	Options for analysing cooked rice for publication in the database and a scientific article
x	Choose to analyse the boiled white rice only, as it is the most common cooking method: boil the rice of the same three regional rice samples as above and analyse them separately. Then calculate the nutrient retention factors, which you can then use to calculate the nutrient values for other boiled rice.
	Choose to analyse one sample of boiled white rice (composite of the three regional samples); one of fried white rice; and one of boiled parboiled rice. In this way, all major cooking methods are analysed.
	Choose to analyse two samples of boiled white rice (one composite of the national sample and one of imported rice), and one of boiled parboiled rice. In this way, boiling as the major cooking method is well defined, also taking account of regional differences.

For your information:
For scientific publications, three analytical samples should be analysed per food. Therefore, the first option is correct. However, in specific cases, compilers might choose options 2 or 3 for reasons of economy – knowing that this approach does not result in high quality information and would likely not be publishable in a scientific journal.

(e) Calculate the sample number for iron in white raw rice (mean from foreign food composition table is 0.5 mg/100 g and the range is 0.1 – 1.3 mg/100 g). An accuracy of 10% and a confidence level of 95% are envisaged. To be able to calculate the sample size, a standard deviation (SD) is needed and three values are necessary calculate SD. For the purpose of this exercise, SD is estimated as 0.6, assuming that the mean is a value so that SD can be calculated. Assume a sample size of 10 for the t value. *(2 points)*

Note**:** for sample size of 10, t = 2.262 and t^2 = 5.1166

sample size > $(t_{\alpha\, n\text{-}1})^2$ x SD^2/ (accuracy x mean)^2

Answer:

SD = 0.6 and SD^2 = 0.36
accuracy = 0.1
mean = 0.5
(accuracy x mean)^2 = 0.0025.

(5.1166 x 0.36) / 0.0025 = 736.8 rounded to 737
It is estimated that about 737 food samples should be analysed for iron in white rice for the variation and confidence indicated.

For your information:
Even though this method can be used to estimate the number of samples needed to obtain results with a certain confidence level, the number of samples to be analysed individually exceeds the financial possibilities of most food composition programmes and therefore is unrealistic. Valuable compositional data can be obtained with fewer samples. As an example is the USA which requires 12 individual analytical samples for labelling purposes.

V.E2 A compiler has sampled apples for analysis and for inclusion in the national food composition database. In each of the four seasons, 10 apples were collected at 12 sample sites throughout the country, including supermarkets, markets and small shops. The 12 sample sites are representative of the 12 regions in the country. *(3 points: 1 point for each correct response)*

Answers:

(a) What number of samples will be indicated in the food composition database if each food were to be analysed separately?

The number of samples to be recorded in the food composition table would be 480 (n = 480). 4 seasons x 10 apples x 12 sample sites = 480.

For your information:
Analytical results from individual samples may be used to calculate the year-round, nationwide mean, regional means or seasonal means. Normally, however, more samples are composited to reduce the cost for analysis.

(b) What number of samples will be indicated in the food composition database if a composite sample were to be prepared and analysed for each season?

The number of samples in the food composition table would be four (n = 4): four seasons. Each analytical sample for the four seasons would comprise 120 food samples: 10 apples x 12 sample sites.

(c) What number of samples will be indicated in the food composition database if all apples were put into one composite sample and analysed in duplicate?

The number of samples in the food composition table would be one (n = 1) even when analysed in duplicate. The analytical sample would comprise 480 individual food samples: 4 seasons x 10 apples x 12 sample sites.

V.E3 As foods are biological material, the same food may have different compositions. Thus, the greater the number of analytical samples contributing to the mean value, the more accurate the data. In the example below, calculate the mean value of the food for the three different sample plans. *(4.5 points: 1 point for each correct calculation and ½ point for each correct response for the interpretation)*

Answer:

Analytical value (mg/100g edible food)	Foods selected through sampling plan		
	Plan 1 (n = 10)	Plan 2 (n = 5)	Plan 2 (n = 1)
52	x		
121	x	x	
88	x		
47	x	x	
39	x		x
94	x	x	
102	x		
83	x	x	
75	x		
66	x	x	
Value in food composition database	76.7	82.2	39

Interpretation:

True	False	Interpretation of V.Q20 on number of samples
	x	No bias is introduced when one sample is taken and analysed (e.g. from the shop around the corner).
x		The more food samples that are collected and analysed separately, the closer the mean value is to the true mean. This approach allows evaluation of the variability in nutritional composition.
	x	The more samples that are taken and analysed as one composite sample, the closer the mean value is to the true mean. This approach allows evaluation of the variability in nutritional composition.

V.E4 One kilogram of analytical sample is needed per replicate to analyse a number of components. The laboratory undertakes all analysis in duplicates. The food has an edible portion of 40% and it is intended to store an additional sample in the deep freezer in case the laboratory loses a sample. Select the weight of the food to be collected. *(1 point)*

Answer:

	Food weight needed
	3400 g
x	7500 g
	4200 g
	3000 g

Calculation
1000 g needed per replicate: 1000 g x 2 = 2000 g
1000 g needed for back-up sample: 1000 g
Total edible sample: 2000 + 1000 = 3000 g
Total food (including inedible part) needed: 3000 g x 100/40 = 7500 g

GENERAL FEEDBACK USING SELF-SCORING

66 – 100.5 points: You have fully understood and integrated the principles of sampling for food composition. Congratulations. You are well prepared to go to the next module and to carry out a simple sampling plan.

46 – 65 points: You have understood and integrated most of the principles of sampling for food composition. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so in order to effectively apply the new knowledge.

21 – 45 points: You have understood and integrated a fair part of sampling for food composition. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

0 – 20 points: It seems you have significant gaps in your understanding of sampling principles for food composition. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

Module 6

QUALITY ASPECTS OF ANALYTICAL DATA

LEARNING OBJECTIVES
By the end of this module the student will be able to:
- understand the principles governing the choice of analytical methods;
- apply these principles in the laboratory or when choosing a laboratory for chemical analysis;
- comprehend the importance and implementation of quality assurance in analytical work.

REQUIRED READING
- **Elliot, J**. Laboratory Quality Systems Assuring Quality in Laboratory performance – Introduction and Overview. A PowerPoint presentation available at: http://wwwn.cdc.gov/dls/ila/cd/guam/files/Module%201-QS%20Overview.ppt#1

and if possible:
- **Greenfield, H. & Southgate, D.A.T**. 2003. *Food composition data – production, management and use.* FAO. Rome. Chapters 5 (p. 79[24]), 6 (pp. 83-96), 7 (pp. 106, 123) and 8 (pp. 149-162). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf
- **Codex Alimentarius.** 2007. *Report of the Twenty-eighth Session of the Codex Committee on Methods of Analysis and Sampling (ALINORM 07/30/23)*, July *2007*, Appendix V. pp. 50-61. Available at: http://www.codexalimentarius.net/web/archives.jsp?lang=en
- **EUROCHEM/CITAC**. 2000. Guide CG4 *Quantifying uncertainty in analytical measurement*. Second edition. QUAM: 2000.1: pp. 3–10. Available at : http://www.eurachem.org/guides/QUAM2000-1.pdf
- **EUROCHEM/CITAC Guide**. 2003. *Traceability in Chemical Measurement – A guide to achieving comparable results in chemical measurements*. pp. 3–14 Available at: http://www.eurachem.org/

EXERCISE MATERIAL
- Web site of the International Laboratory Accreditation Cooperation: http://www.ilac.org/
- Web site of the National Accreditation Board for Testing and Calibration Laboratories: http://www.nabl-india.org/nabl/asp/users/documentMgmt.asp?docType=both

RECOMMENDATION
It may be helpful to complete module 4.d (Component methods of analysis) before question VI.Q2.

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)
- Compilers/ professional users ++
- Analysts +++++

ESTIMATED TIME TO COMPLETE TASKS
- Required reading: 1–3 hours
- Answering the questions: 1–3 hours
- Completing the exercises: 1–3 hours

SUGGESTED ADDITIONAL READING
- **EUROCHEM**. 1998. *The Fitness for Purpose of Analytical Methods - A Laboratory Guide to Method Validation and Related Topics*. Available at: http://www.eurachem.org/guides/valid.pdf.
- **ISO/IEC.** 2005. ISO/IEC 17025. *General requirements for the competence of testing and calibration laboratories*. Edition 2. Available at: http://www.iso.org/iso/Catalogue_detail?csnumber=39883
- **Wolf, W.R. & Andrews, K.W**. 1995. A system for defining reference materials applicable to all food matrices. *Fresenius' Journal of Analytical Chemistry*. 352(1-2):73-6

[24] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to the PDF file.

Answers to the questions

VI.Q1 Explain why a compiler needs to understand the principles governing the choice of analytical methods and laboratory quality assurance schemes. Select True or False. *(2.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 83):

Why a compiler needs to understand the principles governing the choice of analytical methods and laboratory quality assurance schemes	True	False
To be able to select a suitable laboratory	x	
To be able to judge the quality of nutrient values	x	
To be able to calculate recipes		x
To be able to discuss analytical results with analysts	x	
To be able to select appropriate analytical methods relevant for human nutrition	x	

VI.Q2 Laboratory quality has an impact on the quality of nutrient values. Indicate the criteria that determine the quality of compositional data. Select True or False.
(2.5 points: ½ point for each correct response)

Answer (see Greenfield & Southgate, 2003, p. 83):

Criteria	True	False
Careful performance by trained analysts	x	
Choice of appropriate and sensitive analytical method	x	
High budget allocation		x
Laboratory's quality assurance scheme	x	
Sampling and sample handling	x	

VI.Q3 For the following nutrients, indicate the correct category of method adequacy and availability. *(9 points: ½ point for each correct response per component)*

- good methods: extensively evaluated in collaborative trials;
- adequate methods: evaluated with a limited number of studies;
- not adequate for certain foods: not studied on a wide range of food matrices;
- lacking methods: no analytical method available to determine the component; and
- not applicable: not determined using analytical methods or calculated.

Answer (see Greenfield & Southgate, 2003, p. 84):

	Good methods	Adequate methods	Not adequate for certain foods	Lacking methods	Not applicable
Refuse/edible part; energy					x
Water; alcohol; ash	x				
Protein			x		x (if calculated based on total nitrogen)
Nitrogen, total; amino acids	x				
Total carbohydrates by difference					x (because calculated)
Sugars, individual and total; starch	x				
Fat	x				
Cholesterol		x			
Saturated fatty acids; monounsaturated fatty acids; polyunsaturated fatty acids	x		x (some isomeric fatty acids)		
Trans fatty acids		x			
Iron; calcium; magnesium; potassium; zinc	x				
Iodine	x (ICP-MS)	x			
Selenium		x			
Ascorbic acid	x				
Vitamin C		x			
Folate		x		x (some isomers)	
Thiamin; riboflavin; niacin	x				
Vitamin A, total					x (because calculated)
Retinol; carotenes; vitamin D and E isomers		x	x (some carotene isomers)		

For your information:
Adequacy of the method is not the same as an adequate performance of the method. Adequacy of the method indicates whether the method is capable of correctly measuring the component, and only the component of interest (selectivity). The performance indicates whether a laboratory is capable of performing the method correctly, i.e. giving accurate and precise results.

VI.Q4 Match the following terms to the corresponding definition. *(3.5 points)*

Note: It might be helpful also to consult the Codex website, available at:
http://www.codexalimentarius.net/web/archives.jsp?lang=en – ALINORM 07/30/23, appendix V.

Answer (see Greenfield & Southgate, 2003, pp. 87-95 and ALINORM 07/30/23, appendix V):

Terms:
1. Precision
2. Reliability
3. Applicability
4. Accuracy
5. Robustness
6. Sensitivity
7. Specificity

Number	Definition
4	The closeness of agreement between a test result or measurement result and the true value (Codex, 2007).
6	Quotient of the change in the indication of a measuring system and the corresponding change in the value of the quantity being measured (Codex, 2007).
3	The analytes, matrices and concentrations for which a method of analysis may be used satisfactorily (Codex, 2007). It may also include warnings on known interference by other analytes.
7	The ability of a method to measure only the desired substance. Very frequently, methods rely on the absence of interferences to achieve the objective.
1	The closeness of agreement between independent test/measurement results obtained under stipulated conditions. It depends only on the distribution of random errors and does not relate to the true value or to the specified value (Codex, 2007).
5	A measure of the capacity of an analytical procedure to remain unaffected by small but deliberate variations in method parameters. It provides an indication of its reliability during normal use (Codex, 2007).
2	A qualitative term expressing a degree of satisfaction with the performance of a method in relation to applicability, specificity, accuracy, precision, detectability and sensitivity. The type, concentration of the component, and the purposes of the analyses determine the relative importance of the different attributes.

VI.Q5 Indicate the three essential criteria for selecting an analytical method for generating data for a national food composition programme, as suggested by Egan (1974). Select True or False. *(3 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 86-87):

Criteria	True	False
Preference should be given to methods whose reliability has been established by collaborative studies involving several laboratories.	x	
Preference should be given to methods recommended or adopted by a national organization.		x
Preference should be given to methods whose reliability has been established by the main laboratory in the field.		x
Preference should be given to methods of analysis applicable to one specific food matrix.		x
Preference should be given to methods recommended or adopted by international organizations.	x	
Preference should be given to the method applicable to the widest range of food types and matrices rather than those applicable only to specific foods (especially if only a single method is feasible in the laboratory).	x	

VI.Q6 It is possible for laboratories with less-sophisticated equipment to produce good analytical results by applying a labour-intensive but valid analytical method? Select True or False. *(1.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 86):

Statement	True	False
Yes, because the method meets the quality criteria valid and well-trained personnel are capable of carrying out the method correctly.	x	
No, because only sophisticated equipment with automated procedures can produce good-quality results.		x
No, because all manual and labour-intensive analytical methods have a low level of accuracy.		x

VI.Q7 Match the following terms to the corresponding definition. *(3 points: ½ point for each correct response)*

Note: It might be helpful also to consult the Codex website, available at http://www.codexalimentarius.net/web/archives.jsp?lang=en – ALINORM 07/30/23, appendix V

Terms:
1. Repeatability standard deviation
2. Repeatability relative standard deviation
3. Limit of detection (LOD)
4. Limit of quantification (LOQ)
5. Recovery
6. Reproducibility/repeatability

Answer (see Greenfield & Southgate, 2003, pp. 87-95 and appendix V of ALINORM 07/30/23)

Number	Definition
6	Precision under repeatability [reproducibility] conditions (Codex, 2007).
1	Standard deviation of test results or measurement results obtained under repeatability [reproducibility] conditions (Codex, 2007).
5	Proportion or amount of an analyte present in and/or added to the analytical portion of the test material, which is extracted and presented for measurement (Codex, 2007).
3	The amount of an analyte corresponding to the lowest measurement signal, which, with a defined confidence, may be interpreted as indicating that the analyte is present in the test sample, without allowing its quantification. It is conventionally defined as field blank + 3σ, which is the standard deviation of the field blank value signal (IUPAC definition).
4	In terms of an analytical procedure, it is the lowest amount of analyte in a laboratory sample that can be quantitatively determined with a defined confidence (Codex, 2007).
2	Computed by dividing the repeatability [reproducibility] standard deviation by the mean. It is a useful measure of precision in quantitative studies. This is done so that the variability of sets with different means can be compared. Its values are independent of the amount of analyte over a reasonable range. These values facilitate the comparison of variabilities at different concentrations (Codex, 2007).

VI.Q8 Is it necessary for a laboratory to evaluate a well-established method? Explain briefly. *(1 point)*

Answer (see Greenfield & Southgate, 2003, p. 91):

Yes, even well-established methods need to be evaluated with one's own staff, reagents and equipment to determine how well the method performs in one's own laboratory.

For your information:
An evaluation of the attributes of the method should be established under the conditions prevailing in the laboratory and the performance characteristics quantified.

VI.Q9 Determine the correct order of the five steps analysts should take to become acquainted with a new method – 1 being the first step and 5 the last step. *(2.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 91-92):

	Steps needed to become acquainted with a new method
5	Run a trial (and dismiss the results) to check the stages, especially with regard to timing. Less-experienced staff may take time to adjust if there are many critical operations (e.g. as in the non-starch polysaccharide method, where the mixing stages are critical).
3/4	Check the list of reagents required (standardization of some reagents may be needed before the method is started), the concentrations of certain reagents, conditions described, timing and equipment required, and any specifications listed for the equipment.
2	Perform a 'paper exercise' to ensure that the principle of the method is understood.
4/3	Critically assess each stage to fully familiarize with the purpose and logic of the method.
1	Study the formal protocol for the method.

VI.Q10 Metrology is the science of measurement. It permits us to understand the theoretical and experimental determinations and uncertainties of measurements, hence the validity (and reliability) of analytical results. Its main feature is traceability, i.e. every analytical measurement obtained through any analytical method can be validated through a common reference point. Match the following terms to the corresponding definition. *(4 points: ½ point for each correct response)*

Note: It might be helpful also to consult the Codex website, available at: http://www.codexalimentarius.net/web/archives.jsp?lang=en – ALINORM 07/30/23, appendix V, and the EUROCHEM/CITAC Guide, 2003. Available at: http://www.eurachem.org/

Answer (see Greenfield & Southgate, 2003, pp. 87-95, ALINORM 07/30/23, appendix V, and EUROCHEM/CITAC, 2003 pp. 3-14):

Terms:
1. Certified reference material (CRM)
2. Laboratory performance study
3. Interlaboratory study
4. Reference material
5. Validation
6. Calibration
7. Traceability
8. Uncertainty of measurement

Number	Definition
5	A process using objective evidence to confirm that the requirements which define an intended use or application have been met (ISO definition) and are capable of producing the planned results.
3	A study whereby several laboratories measure a quantity in one or more 'identical' portions of a homogeneous and stable test material under documented conditions, the results of which are compiled into a single document (Codex).
8	A parameter associated with the result of a measurement, which characterizes the dispersion of the values that could reasonably be attributed to the measurand (analyte).
2	Process consisting of one or more measurements by a group of laboratories on one or more homogeneous and stable test samples by the method selected or used by each laboratory. The reported results are compared with those from other laboratories or with the known or assigned reference value, usually with the objective of improving laboratory performance. It is also called proficiency testing (Codex).
1	Material accompanied by an authenticated certificate having for each specified quantity a value, a measurement uncertainty and stated metrological traceability chain (Codex).
7	Property of the measurement result relating the result to a stated reference or the value of a standard whereby it can be related to stated references through an unbroken chain of comparisons, each contributing to the stated measurement uncertainty (Codex).
4	Material, sufficiently homogenous and stable with respect to one or more specified quantity. It is used to calibrate measuring systems, assess a measurement procedure or to assign values and measurement uncertainties to quantities of the same kinds of materials (Codex).
6	A process to validate a specific measurement technique and equipment or to establish the relationship between a measuring device and the units of measure. It compares a devise or measurement with *unknown* magnitude or accuracy to a devise or measurement with a *known*, accurate standard (e.g. CRM).

For your information:
In contrast to metrology and its principle of traceability, AOAC identifies and validates analytical methods able to produce valid results.

Validation is important in establishing traceability through demonstrating that the calculation and measurement conditions of the method include all the "influence quantities" significantly affecting the result, or the value assigned to a standard.

Calibration is also a fundamental process of establishing traceability and validates laboratory performance. It can be (and usually is) applied to parts of a measurement system. In particular, instruments are normally calibrated in isolation and then used in a larger measurement system. Items such as balances and thermometers are calibrated less frequently because they are relatively stable in the medium term; instruments such as GC or ICP equipment tend to vary much more and are typically calibrated more frequently, often in the same run as a set of test items. For this purpose, one would generally use a pure chemical as the calibration material, though it may be added to a matrix similar to the samples expected in order to reduce matrix effects. Under these circumstances, the reference standard values will appear in the calculation of the result (perhaps indirectly) and it is therefore clear that the result is traceable to these reference values (EUROCHEM/CITAC Guide, 2003).

VI.Q11 From the following techniques, select those that allow the laboratory to validate its own performance within or with other laboratories. Note that some techniques may apply to both validation types. *(3.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 155-158):

Techniques	Within laboratory validation	Between laboratory validation
Recovery study	x	
Replicate determination	x	
Use of standard and authentic samples	x	
Use of normal/routine samples with varying concentrations	x	
Use of food samples analysed by different methods	x	x
Analysis carried out by second analyst	x	x
Collaborative studies		x

VI.Q12 Determine the order of the following reference material from high to low – 1 being the highest and 3 the lowest – for quality and cost. *(3 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 93-94 and 155-157):

Reference material	Quality	Cost
Standard/certified reference material	1	1
Standard/authentic sample	3	3
In-house reference material	2	2

Optional question for those with advanced knowledge or who have participated in a food composition course
VI.Q13 Pure substance reference material (e.g. a pure metal) can be used to establish traceability back to an SI unit, but in many cases the uncertainty of the result is unacceptably high. Therefore, certified reference material (CRM), also called standard reference material (SRM), with certified values is often used to establish traceability back to an SI unit. It also has the advantage of being a food with a specific matrix and the certification applies to the specific matrix and a concentration. Secondary reference material is produced nationally, calibrated

through a CRM, and can be used routinely in analytical determination. Tertiary reference materials are normally produced in-house in a laboratory and are calibrated through a CRM or through secondary reference materials for certain measurands (analytes). Match the following terms on reference materials to the corresponding statement. Several responses are possible in one answer. *(2.5 points: ½ point for each correct response)*

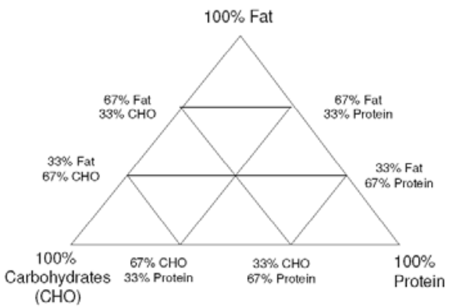
Note: See also EUROCHEM/CITAC Guide CG 4, Second Edition. 2000. *Quantifying uncertainty in analytical measurement.* QUAM:2000.1. pp. 9-10, available at:
http://www.eurachem.org/guides/QUAM2000-1.pdf

Terms related to reference materials:
1. 'Pure substance reference material'
2. 'Certified reference material'
3. 'Secondary reference material'
4. 'Tertiary reference material or in-house reference material'

Answer (see EUROCHEM/CITAC Guide, 2000 pp. 9-10):

	Statements on reference material
2	Natural matrix material supplied by internationally-recognized institutions, which can be spiked with certain compounds. It is certified for a certain number of analytes at a specific concentration level, and is used to calibrate instruments while ensuring that a specific food matrix does not create interference.
4	Reference material often produced within the laboratory with an analyte-specific matrix. It is often of higher quality than standard or authentic samples, and is used in routine work to monitor method performance.
1	Highest purity substance supplied by internationally-recognized institutions, representing metrological excellence because of highest guarantee of accuracy. It can be used to calibrate CRMs and methods.
1,2	It can be used to establish long-term measurement traceability, to identify and develop accurate analytical methods, and to validate independent methods. It is the only reference material that can be used to satisfy regulatory needs.
3	It is often cheaper and of lower guarantee of accuracy than CRM, and is used to produce in-house reference material. It is produced at the national or regional levels.

Optional question for those with advanced knowledge or who have participated in a food composition course
VI.Q14 Wolf and Andrews (1995) suggest that all foods can be classified into one of the nine fields of the pyramid below. They propose that foods falling within the same sector would be chemically similar and thus should behave in a similar analytical manner. Therefore, the same CRM could be used. Indicate the correct statements concerning the matrix and the choice of an appropriate CRM. Select True or False. *(1.5 points: ½ point for each correct response)*



Answer:

Correct statements concerning CRM	True	False
The protein, fat and carbohydrate contents of the food to be analysed has to be taken into account in the choice of the appropriate CRM.	x	
Protein is the only component of the matrix of the CRM that causes interference.		x
CRMs have been developed for each of these nine groups and, in general, they can be used for all foods in this group.	x	

For your information:
It is especially the fat content that needs to be similar between the CRM and the food to be analysed because it is a major factor of the matrix in the CRM that causes interference with some components.

Even being in the same group, the matrix of human and cow's milk is very different, especially for the phosphorus content that causes interference. A specific CRM of human milk is therefore needed when analysing such milk.

Optional question for those with advanced knowledge or who have participated in a food composition course
VI.Q15 Indicate the criteria for an in-house quality control sample or in-house reference material. Select True or False. *(2 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 93-94, 155-157):

Criteria for an in-house quality control sample	True	False
Homogenous	x	
Similar matrix to test sample. The matrix and analyte should be stable over time	x	
Similar matrix to test sample and a known and certified quantity of the analyte		x
Reasonably cheap and readily available in sufficient quantities	x	

VI.Q16 Which of the following materials are often used as in-house reference materials? Select True or False. *(5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 94):

Materials are often used as in-house reference material	True	False
Non-segregating powders, such as non-fat milk powders	x	
Egg powder		x
Fish oil		x
Powder mixes for parenteral feeds	x	
Soybean meal	x	
Fishmeal/fish flour	x	
Milk		x
Gelatine	x	
Breakfast cereals		x
Flour	x	

VI.Q17 Match the three types of collaborative studies to their purpose. *(1.5 points: ½ point for each correct response)*

Types of collaborative studies:
1. Round-robin or ring test
2. BCR (Community Bureau of Reference) type
3. AOAC type

Answer (see Greenfield & Southgate, 2003, p. 95):

Type	Purpose
2	To develop certified materials
3	To establish the performance of a method
1	To provide comparative assessments of laboratory performance

Optional question for those with advanced knowledge or who have participated in a food composition course
VI.Q18 Different z–scores or SD values are recommended to scrutinize analytical (or other) values. Two examples: (1) ISO 8258:1991 (Shewhart control chart) uses 2 SD for warning and 3 SD for corrective actions; and (2) ASEANFOODS accepts national values if they are within 3 z-scores and international values within 5 z-scores. Why are the scrutiny values different for different purposes? Select True or False. *(1 point)*

Answer:

Criteria for data scrutiny	True	False
The more similar the food samples, the smaller the SD or z-score should be around the mean.	x	
Any laboratory should be able to generate values within 2 SD for similar foods.		x
If in a set of data, values with diverse quality and origin are included (e.g. non-analytical or from different sources), the z–score or SD can be higher because of a higher expected variability.	x	

VI.Q19 Indicate the purpose of the following checks by selecting 'Preparation, e.g. of the laboratory sample', 'Analytical method', or 'Calculations'. Some statements may have two correct answers. *(7 points: ½ point for each correct response)*

Note: Calculations should not be selected if a calculation step is needed while the check is done for another purpose. For example, checking the correct dilution of a laboratory sample corresponds to 'Preparation e.g. of laboratory samples'.

Answer (see Greenfield & Southgate, 2003, pp. 79, 96, 106, 123, 155-162)

Checks	Preparation, e.g. of laboratory sample	Analytical method	Calculations
Check key-step performance of the method		x	
Carry out a recovery study		x	
Recalculate recovery			x
Check calculations, including all the secondary operations such as derivation of equations, simple mathematical operations, units			x
Check destruction of the matrix (for ash)	x	(x)	
Check completeness of extraction and saponification		x	
Check performance of the analytical equipment		x	
Carry out replications of determinations		x	
Check homogeneity of food sample	x		
Use homogenous reference material		x	
Check composition and concentration of solutions	x	x	
Run blind analysis		x	
Run standard curves		x	
Check measurement of recorder peaks			x

VI.Q20 Briefly describe three common procedures that may lead to systematic errors in analytical values. *(3 points: 1 point for each correct response)*

Answer (see Greenfield & Southgate, 2003, p. 96, table 6.2):

Your answer should include any three of the following (the list might not be exhaustive):

- If analytical samples are of similar or identical size when used for replicate analysis and if there is an error in the concentration calculation, the error cannot be detected because the analytical size and denominator are the same.
- Reagents are always from the same batch: if there is an error in one batch of the reagent, it can only be detected if another batch of reagent is used for a similar analysis.
- Standard solutions are used from the same stock of the same series of dilutions: if there is an error in one series of dilutions, it can only be detected if a standard solution from another series of dilutions is used for a similar analysis.
- The replication of analyses is done on the same batch of food sample and/or at the same time: if there is an error in the analytical sample preparation, it can only be detected if another analytical sample is used or if it is analysed by another laboratory. As several variables influence the day-to-day variability, it might be better to analyse replicates on different days.
- Only one analyst carries out the analyses: if there is an error in the performance of the analyst, it can only be detected if another analyst carries out the same analysis or if the analysis is performed by another laboratory.
- Only one procedure is used: if there is an error in the analytical procedure, it can only be detected if another method based on different principles is used or if the procedure is used on the same samples by another laboratory.

VI.Q21 Match the following terms to the corresponding definition: *(2 points: ½ point for each correct response)*

Terms:

1. Data quality
2. Quality control
3. Quality assurance/quality assurance programme
4. Good laboratory practices

Answer (see Greenfield & Southgate, 2003, p. 150):

Number of term	Definition
3	A programme of planned and systematic actions to provide adequate confidence that the product or service will satisfy given requirements for quality (fit for purpose). This includes objective measures to evaluate the laboratory's performance. The objective is to improve and stabilize performance.
1	Summary of all features that make the values appropriate for the intended use.
2	Operational techniques and activities used to satisfy quality requirements. The objective is to test the product or service to detect eventual errors.
4	The organizational process and the conditions under which laboratory studies are planned, performed, monitored, recorded and reported.

VI.Q22 All tasks of a quality assurance programme (QAP) can be categorized. *Preventive measures* are taken prior to the analysis to ensure accuracy in the analytical testing. *Assessment measures* are procedures undertaken during the analysis to ascertain that the system is performing correctly. *Corrective measures* are taken when an error is detected and corrected. Assign the following elements of a QAP to the corresponding category: 'Measures to prevent errors', 'Measures to assess method performance' and 'Measures to correct errors'. *(7.5 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 151-162):

Elements of QAP	Measures to prevent errors	Measures to assess method performance	Measures to correct errors
Proper use of controls and reference standards		x	
Adequate qualification and motivation of staff, and continuous training	x		
Replacement of faulty reagents			x
Quality control of reagents, glassware and solvents	x		
Quality control of the operation of instruments and other equipment	(x)	x	
Laboratory manager with QAP responsibilities	x		
Investigation of unusually high or low values, including repeated analyses; checking possible loss or contamination of analyte; rechecking calculations		x	(x)
Well-organized space in laboratory; good ventilation and fume hoods; adequate power supply; and adequate quality and volume of distilled water and reagents	x		
Recalibration			x
Avoidance of contamination	x		
Development of quality assurance manual for regular consultation by staff	x		
Maintenance of a proper record-keeping system for analytical results	(x)	x	
Schedules for regular servicing, testing and replacement of equipment	x		
Careful scrutiny of results, including comparison with those of other laboratories; selection of repeat analyses		x	
Close attention to all aspects of food sampling; adequate storage of food samples	x		

For your information:
In general, the better the preventive measures work the less corrective measures are needed.

VI.Q23 Indicate the correct statement(s) concerning recovery studies. Select True or False.
(2 points: ½ point for each correct response)

Answer (see Greenfield & Southgate, 2003, pp. 158-159, 162):

True	False	Statements concerning recovery studies
x		Recovery studies are used to monitor the accuracy of a method.
	x	Recovery studies are used to determine whether or not an analytical method adequately identifies different concentrations of intrinsic components in a food sample.
	x	Recovery studies with added constituents indicate whether the method is capable of determining the content of endogenous constituents in the food matrix.
x		The recovery is assessed by the ratio between the observed analysed concentration and a material containing the analyte at a reference level.

VI.Q24 Control charts are used to check the validity of analytical values. Select True or False.
(1.5 points: ½ point for each correct response)

Answer (see Greenfield & Southgate, 2003, p. 156):

Statements about control charts	True	False
A control chart is a graphical chart with control limits and plotted values of some statistical measure for a series of samples or subgroups. A central line (the mean) is commonly shown. The results of a laboratory test are plotted on the vertical axis, versus the time (in hours, days, etc. – ideally up to 3 months) plotted on the horizontal axis.	x	
A control chart indicates a problem if the analytical results are randomly distributed above and under the mean and within the control line.		x
A control chart indicates a problem if the analytical results show an upward or downward trend, if one value is outside the control line, or if several consecutive values are under (or over) the mean.	x	

VI.Q25 From the following statements, select those that describe analytical variation or nutrient variation in foods. Put 1 for analytical variation and 2 for nutrient variation in foods.
(3 points: ½ point for each correct response)

Answer (see Greenfield & Southgate, 2003, pp. 158-159, 162):

	Statements concerning (1) analytical variation or (2) nutrient variation in foods
1	Analysis of food samples in replicates
2	Analysis of varieties/cultivars/breeds of the same food
1	Analysis using different analytical methods
1	Analysis by different analysts
1	Analysis of the same sample by several laboratories
2	Analysis of a food from different regions or seasons

VI.Q26 Indicate the correct statement(s) about accredited laboratories. Select True or False.
(2.5 points: ½ point for each correct response)

Note: See also the web site of the International Laboratory Accreditation Cooperation http://www.ilac.org/.

Answer:

Statements about accredited laboratories	True	False
Accredited laboratories have an adequate QAP in place and are certified by a national or international organization.	x	
By definition, an accredited laboratory is accredited for all analytical methods and food matrices.		x
A high-quality QAP is synonymous with accreditation.		x
Analyses carried out by an accredited laboratory are generally more expensive than those done by a non-accredited laboratory because QAP is costly.	x	
Accredited laboratories are regularly assessed by the accreditation body to ensure sustainability of accreditation.	x	

SAMPLE ANSWERS TO THE EXERCISES

VI.E1 In India, a small laboratory wishes to become nationally accredited for vitamin C analysis in fruits and for protein in meat. Over the last 10 years, it has used HPLC for vitamin C and the Kjeldahl method for protein. It has never participated in any proficiency testing or collaborated with other laboratories to test its performance. When looking at documents on the web site of the National Accreditation Board for Testing and Calibration Laboratories (NABL), at http://www.nabl-india.org/nabl/asp/users/documentMgmt.asp?docType=both, it found that it needed to carry out a number of tasks before obtaining accreditation. Indicate the category to which each tasks in the accreditation process belongs: Preparatory phase, Method improvement, Improvement of facilities and other issues or Accreditation exam. *(11½ points: ½ point for each correct response)*

Answer:

Tasks	Preparatory phase	Method improvement	Improvement of facilities and other issues	Accreditation exam
Participate in an interlaboratory study		x		
Discuss the process with all staff concerned; read and discuss all documents	x			
Discuss progress on analytical results with all staff concerned		x		
Receive accreditation certificate				x
Improve laboratory performance because your results do not compare well with those of other laboratories		x		
Train staff in the method	(x)	x		
Prepare visit of inspector				x
Improve fume cupboard, ventilation, electric power supply (to avoid electrical cuts) and fire security measures			x	
Send a staff member to work in an accredited laboratory for a period of one year, to subsequently serve as quality assurance manager after return	x	(x)		
Improve calibration and reference material used		x		
Improve homogenizer, sample storage (to avoid cross-contamination and loss of nutrients) and documentation			x	
Prepare a quality assurance manual for circulation to staff	x			
Send application form to NABL				x
Improve record-keeping, maintenance and archiving to cover all purchases of consumables, supplies and equipment			x	
Check whether analytical methods are in accordance with Codex guidelines	(x)	x		
Improve identification, control and corrective action with respect to non-conformity of results		x		
Improve reporting of results			x	
Improve traceability of sample portions to original food sample(s)			x	
Decide whether the laboratory meets all criteria for accreditation				x
Update records of staff qualifications, training and job descriptions			x	
Obtain commitment from top management to initiate accreditation process	x			
Ensure that the objective of accreditation is valid	x			
Appoint and authorize a quality manager	x			

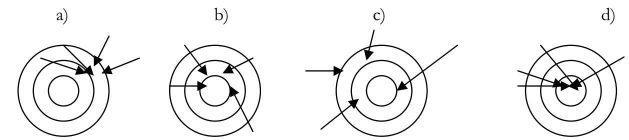
For your information:
In most cases, the improvement of facilities and methods occurs in parallel. It might be useful to participate in a second interlaboratory study, especially if participation in the first interlaboratory study was unsuccessful. Satisfactory results would then demonstrate that the laboratory is performing well, also in comparison with other laboratories. Quality assurance is a continual process.

VI.E2 Draw four arrows into each target to demonstrate:

a) a precise but not accurate method;
b) an accurate but not precise method;
c) a method that is neither precise nor accurate;
d) a precise and accurate method (= reliable).

(4 points: 1 point for each correct response)

Answer:



For your information:
A precise but not accurate method gives results that are close to one another but are far from the true value. An accurate, but not precise, method provides values that are close to the true value but disperse around it. A method that is neither precise nor accurate delivers values that are randomly distributed but are neither close to nor around the true value. A precise and accurate method is the best method because all values are close to the true value.

GENERAL FEEDBACK USING SELF-SCORING

Analysts and other professionals working in a laboratory should achieve the first two categories, whereas it is sufficient for compilers and professional users to achieve the last two.

71 – 96.5 points: You have understood well and integrated the issues governing 'Quality aspects of analytical data'. Congratulations. You are well prepared to apply the issues in your work.

46 – 70 points: You have understood and integrated most of the issues on 'Quality aspects of analytical data'. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. You are advised to do so before being able to apply these issues in your work.

21 – 45 points: You have understood and integrated a fair part the issues on 'Quality aspects of analytical data'. You should strengthen your knowledge by returning return to the sections where you did not obtain all possible points. It is highly recommended that you do so before being able to apply the issues in the laboratory. If you are a compiler or professional user, your knowledge is good.

0 – 20 points: You appear to have significant gaps in your understanding of the issues on 'Quality aspects of analytical data'. You should read the sections again and improve your knowledge of these topics before being to apply the issues in the laboratory. If you are a compiler or professional user, your knowledge might be sufficient.

Module 7

RESOURCES FOR FOOD COMPOSITION
PUBLISHING FOOD COMPOSITION DATA

LEARNING OBJECTIVES

By the end of this module the student will:

- know where to locate resources for food composition, e.g. for data, standards, and other technical documents;
- be able to judge the quality of different categories of publications;
- be aware of the requirements to write and submit a scientific article and to apply them when writing articles.

REQUIRED READING

- **Greenfield, H. & Southgate, D.A.T**. 2003. *Food composition data – production, management and use.* FAO. Rome. Chapters 10 (pp. 171-173 of the book and not of the PDF file). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf

EXERCISE MATERIAL

- Guide for Authors. *Journal of Food Composition and Analysis* (JFCA). Available at http://www.elsevier.com/wps/find/journaldescription.cws_home/622878/authorinstructions#
- Some of the resources indicated

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts ++

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1–2 hours
- Answering the questions: 1–2 hours
- Completing the exercises: 1–2 hours

RESOURCES

Websites and books

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use.* FAO, Rome. Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf
- INFOODS website: http://www.fao.org/infoods/index_en.stm
- EuroFIR website: http://www.eurofir.org/eurofir/
- United States Department of Agriculture website: http://www.ars.usda.gov/AboutUs/AboutUs.htm?modecode=12-35-45-00

Food composition tables and databases

- Global repository
  - by region, including older ones: http://www.fao.org/infoods/directory_en.stm
  - in alphabetic order, with web links: http://www.langual.org/langual_linkcategory.asp?CategoryID=4&Category=Food+Composition
- European databases:
  - EuroFIR partners and other European databases: http://www.eurofir.org/eurofir/EuropeanDatabases.asp
  - **Schlotke, F & Moeller, A.** 2000. *Inventory of European Food Composition Databases and Tables.* Available at: ftp://ftp.fao.org/ag/agn/infoods/42867747.pdf

Components nomenclature

- **Klensin, J.C., Feskanich, D., Lin, V., Truswell, S.A. & Southgate, D.A.T**. 1989. *Identification of Food Components for INFOODS Data Interchange.* UNU, Tokyo. Available at: http://www.unu.edu/unupress/unupbooks/80734e/80734E00.htm or as PDF file at; ftp://ftp.fao.org/es/esn/infoods/Klensinetal1989Identificationoffoodcomponents.pdf
- INFOODS tagnames. Available at: http://www.fao.org/infoods/tagnames_en.stm
- EuroFIR component, version 1.1 in EuroFIR thesaurus. Available at: http://www.eurofir.org/eurofir/EuroFIRThesauri.asp . And version 1.0 at: http://www.eurofir.org/eurofir/Downloads/Thesauri/EuroFIR%20Thesauri%202008.pdf and http://www.eurofir.org/xml/EuroFIR_Component_Thesaurus_version_1_0_num.txt

Food nomenclature

- INFOODS food nomenclature. Available at http://www.fao.org/infoods/nomenclature_en.stm
- EuroFIR LanguaL Food Description Thesaurus and the Food Product Indexer. Available at http://www.eurofir.org/eurofir/FoodDescriptionII.asp

Taxonomic websites

- http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl
- http://mansfeld.ipk-gatersleben.de/ http://www.plantnames.unimelb.edu.au/Sorting/Frontpage.html
- http://www.seedtest.org/en/home.html
- http://www.fao.org/figis/servlet/static?dom=org&xml=sidp.xml&xp_lang=en&xp_banner=fi
- http://www.fishbase.org/home.htm and http://www.fishbase.org/search.php
- http://vm.cfsan.fda.gov/%7Efrf/rfe0.html

Yield and retention factors, and recipe calculation

- **EuroFIR** website on recipe calculation, including yield and retention factors. Available at: http://www.eurofir.org/eurofir/RecipeCalculation.asp :
  - **Bell *et al.*** 2006. *Report on Nutrient Losses and Gains Factors Used in European Food Composition Databases* (D1.5.5)
  - **Vásquez-Caicedo, A.L., Bell, S. & Hartmann, B.** April 2007. *Report on collection of rules on use of recipe calculation procedures, including the use of yield and retention factors for imputing nutrient values for composite foods* (D2.2.9)
  - **Reinivuo, H. & Laitinen, K.** April 2007. WP2.2 *Composite Foods: Harmonisation of Recipe Calculation Procedures* (D2.2.12/M2.2.4)
  - **Reinivuo, H.** May 2007. *Inventory of recipe calculation documentations of EuroFIR partners.* An annex to the report 'Proposal for the harmonisation of recipe calculation procedures' (D2.2.12/M2.2.4)
- **Bergström, L.** 1994. *Nutrient Losses and Gains.* Statens Livsmedelsverk, Uppsala. Available at http://www.slv.se/upload/dokument/rapporter/mat_naring/1994_32_Livsmedelsverket_nutrient_losses_and_gains.pdf
- **Bognár, A.** 2002. *Tables of weight yield of food and retention factors of food constituents for the calculation of nutrition composition of cooked foods* (dishes). Bundesforschungsanstalt für Ernährung, Karlsruhe. Available at: http://www.bfel.de/cln_045/nn_784780/SharedDocs/Publikationen/Berichte/bfe-r-02-03,templateId=raw,property=publicationFile.pdf/bfe-r-02-03.pdf
- ***McCance & Widdowson's** the Composition of Foods.* 2002. Summary Edition (Sixth Edition). Royal Society of Chemistry. Food Standards Agency, Cambridge, United Kingdom. pp. 431-440.
- **USDA**. 1975. Agriculture Handbook No. 102. *Food Yields Summarized by Different Stages of Preparation.* USDA Agricultural Research Service, Washington, D.C. Available at: http://www.nal.usda.gov/fnic/foodcomp/Data/Classics/ah102.pdf.
- **USDA. 2003.** *Table of Nutrient Retention Factors, Release 5.* Available at: http://www.nal.usda.gov/fnic/foodcomp/Data/index.html#retention
- **Rodriguez-Amaya, D.B.** 1997. *Carotenoids and Food Preparation: The Retention of Provitamin A Carotenoids in Prepared, Processed, and Stored Foods.* Available at http://www.mostproject.org/PDF/carrots2.pdf

- **Rodriguez-Amaya, D.B.** 1999. *Carotenoides y Preparacion de Alimentos: La Retención de los Carotenoides Provitamina A en Alimentos Preparados, Procesados Almacenados.* JSI. Available at http://www.inta.cl/latinfoods/TEXTO%20FINAL%20COMPLETO%20CON%20TAPAS%20.pdf
- **JFCA Special Issue**. 2006. After Processing: The Fate of Food Components. *Journal of Food Composition and Analysis* 19 (4): 251-394. Available at: http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%236879%232006%23999809995%23620669%23FLA%23&_cdi=6879&_pubType=J&_auth=y&_acct=C000047720&_version=1&_urlVersion=0&_userid=927244&md5=83c9235f41a18e28b10082c2812db0d7

International chemical conventions, standards and dictionaries – available as follows:

- http://physics.nist.gov/cuu/Units/index.html
- http://www.iupac.org/publications/compendium/index.html
- http://www.convert-me.com/en/
- http://www.chem.qmw.ac.uk/iupac/
- ISO online: www.iso.org
- http://www.ebi.ac.uk/chebi/
- http://www.inchem.org/pages/icsc.html
- http://www.cas.org/expertise/cascontent/registry/regsys.html
- http://chembiofinder.cambridgesoft.com/chembiofinder/SimpleSearch.aspx

Scientific journals with compositional data (list adapted from P. Hulshof)

- Journal of Food Composition and Analysis (Available at: http://www.elsevier.com/wps/find/journaldescription.cws_home/622878/description#description)
- Food Chemistry
- Journal of Agricultural and Food Chemistry
- Journal of Nutrition
- American Journal of Clinical Nutrition
- Journal of the Science of Food and Agriculture
- European Journal of Clinical Nutrition
- British Journal of Nutrition
- Journal of Dairy Science
- Journal of Food Science and Technology
- The Journal of Dairy Research
- Horticultural Science
- African Crop Science Journal
- Potato Research
- Cereal Sciences

Online access to scientific journals with compositional data

- AGORA (= Access to Global Online Research in Agriculture) give free or low-cost access to 913 scientific journals in 69 countries. Available at: http://www.aginternetwork.org
- Directory of Open Access Journals (DOAJ). Available at: http://www.doaj.org/
- OPEN ACCESS journals and e-print archives. Available at: http://www.lr.mdx.ac.uk/tempus/syria/openaccess/

Scientific search engines

- Abstracting databases
    - CAB
    - FSTA
    - Science Direct

- For scientific/primary literature
    - Scirus: http://www.scirus.com)
    - Google Scholar: http://scholar.google.com
    - Scopus: http://www.scopus.com
- For scientific/primary and secondary literature
    - FAO virtual library, also books, reports, etc. Available at: http://www.fao.org/waicent/portal/Virtualibrary_en.asp
    - The NAL Catalogue (AGRICOLA) on agricultural literature. Available at: http://agricola.nal.usda.gov/
    - AGRIS. Available at: http://www.fao.org/Agris/
    - google: google.com

Bioactive components

- EuroFIR BASIS database. Available at: http://www.polytec.dk/eBasis/Default.asp
- USDA for phytoestogenes (isoflavones, flavonoids, cholines and proanthocyanidin): http://www.ars.usda.gov/Services/docs.htm?docid=6382

Contaminants

- **Codex Alimentarius**: *Maximum permitted levels, maximum residue levels*: http://www.codexalimentarius.net/mrls/pestdes/jsp/pest_q-e.jsp and http://www.codexalimentarius.net/mrls/vetdrugs/jsp/vetd_q-e.jsp
- **WHO**, 2009. *GEMS/FOOD database*. Available at: http://www.who.int/foodsafety/chem/gems/en/index.html
- National or regional contaminants databases. Examples:
    - Europe (http://ec.europa.eu/food/food/chemicalsafety/contaminants/index_en.htm)
    - Total Diet Studies. Examples:
        - Australia: http://www.foodstandards.gov.au/monitoringandsurveillance/australiantotaldiets1914.cfm
        - France: http://www.afssa.fr/Documents/RapportEAT1EN.pdf
        - New Zealand: http://www.nzfsa.govt.nz/science/research-projects/total-diet-survey/
        - USA: http://vm.cfsan.fda.gov/~comm/tds-toc.html
        - Cameroon (see article at http://www.informaworld.com/smpp/content~content=a791515753~db=all~order=page)

Nutrition labelling

- **Codex Alimentarius.** 2001. *Food Labelling - Complete Texts - Revised.* FAO, Rome. Available at: (http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/005/Y2770E/Y2770E00.HTM_)
- **European Union**. Available at: http://ec.europa.eu/food/food/labellingnutrition/foodlabelling/index_en.htm
- **FDA: NLEA**. 1990. *Nutrition labelling of food.* Available at: http://www.cfsan.fda.gov/~lrd/CFR101-9.HTML

Interchange/ Database management

- **FAO**, 2004. *Report of the Technical Workshop on Standards for Food Composition Data Interchange*. FAO, Rome. Available at: ftp://ftp.fao.org/es/esn/infoods/interchange.pdf
- **Klensin, J.C.** 1992. *INFOODS food composition data interchange handbook*. United Nations University Press, Tokyo, Japan. Available at: http://www.unu.edu/unupress/unupbooks/80774e/80774E00.htm or as PDF file at ftp://ftp.fao.org/es/esn/infoods/Klensin%201992INFOODSDataInterchangeHandbook.pdf

- **Schlotke, F., Becker, W., Ireland, J., Møller, A., Ovaskainen, M.L., Monspart, J. & Unwin, I.** 2000. Eurofoods recommendations for food composition database management and data interchange. Report No. EUR 19538. *Office for Official Publications of the European Communities, Luxembourg.* Available at: ftp://ftp.fao.org/ag/agn/infoods/EurofoodsRecommendations.pdf
- EuroFIR technical website on Systems Development Task Group (WP1.8 TG3), several documents: http://www.eurofir.org/eurofir/SystemsDevelopment.asp
- Compilation Tool version 1.2.1. Available at: http://www.fao.org/infoods/software_en.stm

Training and conferences

- INFOODS training website: http://www.fao.org/infoods/training_en.stm, on international food data conferences: http://www.fao.org/infoods/food_data_conf_en.stm and on conferences related to food composition and nutrition: http://www.fao.org/infoods/meetings_en.stm
- United Nations University website on Capacity Development: http://unu.edu/capacitybuilding/index.htm and Capacity Development through E-learning Workshop: http://www.unu.edu/elearning/workshop_200811/ (this link needs to be copied into the internet address field)

Analytical methods

- List of essential books for food composition databases (appendix 7, pp. 226-268 of Greenfield & Southgate (2003)
- **AOAC** homepage: www.aoac.org
- **AOAC**: recent standard publications in AOAC methods, available at: http://eoma.aoac.org/
- **CEN** (European Committee for Standardization) standards. CEN/TC 275 Food analysis - Horizontal methods, e.g. CEN TC 275 WG 9 – Vitamins and Carotenoids. Available at: http://www.nal.din.de/gremien/CEN%2FTC+275/en/54740484.html
- 'IUPAC Compendium of Chemical Terminology - the Gold Book'. Available at: *http://goldbook.iupac.org/index.html*

Quality of analytical data

- **Codex Alimentarius.** 2007. *Report of the Twenty-eighth Session of the Codex Committee on Methods of Analysis and Sampling (ALINORM 07/30/23), July 2007*, Appendix V. pp.50-61. Available at: http://www.codexalimentarius.net/web/archives.jsp?lang=en
- **EUROCHEM/CITAC**. 2000. Guide CG4. *Quantifying uncertainty in analytical measurement*. Second edition. QUAM: 2000.1:pp. 3–10. Available at: http://www.eurachem.org/guides/QUAM2000-1.pdf
- **EUROCHEM/CITAC Guide**. 2003. *Traceability in Chemical Measurement – A guide to achieving comparable results in chemical measurements*. pp. 3–14 Available at: http://www.eurachem.org/
- **EUROCHEM**. 1998. *The Fitness for Purpose of Analytical Methods - A Laboratory Guide to Method Validation and Related Topics*. Available at: http://www.eurachem.org/guides/valid.pdf.
- **Elliot, J**. 'Laboratory Quality Systems Assuring Quality in Laboratory Performance – Introduction and Overview.' A power point presentation available at: http://wwwn.cdc.gov/dls/ila/cd/guam/files/Module%201-QS%20Overview.ppt#1
- Website of the International Laboratory Accreditation Cooperation: http://www.ilac.org/
- **ISO/IEC.** 2005. ISO/IEC 17025. *General requirements for the competence of testing and calibration laboratories*. Edition 2. Available at: http://www.iso.org/iso/Catalogue_detail?csnumber=39883

Answers to the questions

VII.Q1. Match the terms below with the corresponding description and advantages/disadvantages. *(4 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 171-173):

Terms:
1. Primary publications
2. Secondary publications
3. Unpublished reports
4. Analytical reports

Term	Description
4	They usually contain data from analyses carried out specifically for a food composition programme, or for other purposes.
1	They comprise scientific, peer-reviewed articles.
3	They comprise documents ranging from analytical records to reports prepared for internal use only (e.g. reports of companies, institutes or organizations).
2	Examples are reviews or published compilations, food composition tables and databases, non-peer reviewed literature or books. Some resources in this category are not available through the usual bibliographic databases or indexes and are called 'gray literature' (e.g. technical reports, fact sheets, newsletters, bulletins, working papers, posters, proceedings or thesis).

Term	Advantages/disadvantages
2	May represent a large collection of food compositional data compiled in accordance with international standards (e.g. food composition databases), but the full documentation is not always available to the public.
1	Published food compositional data reviewed by experts. These are not always relevant to or adequate for a national food composition database because the data might be generated for another purpose than representing the compositional data in foods in a given country.
4	Published food compositional data that is not reviewed by experts. They may be generated for food composition purposes or not. Data generated for other purposes makes them less relevant to or adequate for a national food composition database.
3	Include data that are not readily available to the public but may be relevant and include good-quality food composition data.

VII.Q2 Select the correct statement on the relationship between the data documentation found in resources and publications and their quality assessment. *(1 point)*

Answer (see Greenfield & Southgate, 2003, pp. 171-173):

	Relationship between documentation found in resources and publications and quality assessment criteria
	Formal quality criteria cannot be applied to food composition data from resources without appropriate documentation.
x	The application of formal quality criteria to food composition data from resources without appropriate documentation will result in a poor score.
	Full documentation of food composition data is not necessary in order to evaluate their quality.

For your information:
The documentation of food composition data is essential for evaluating their quality. Therefore, data without documentation, or with insufficient documentation, are of lower quality. Very often,

documentation is insufficient and it is necessary to contact the originator/author of the data for further information.

VII.Q3 Determine the order of priority of the literature according to the quality of data for food composition purposes, 1 being the highest and 6 the lowest quality. *(3 points: ½ point for each correct response)*

Answer (see Greenfield & Southgate, 2003, pp. 171-173):

Literature	Order
- Well-documented scientific articles or unpublished reports covering foods from other countries - Food composition databases from other countries with documentation at the value level	3
- Well-documented scientific articles or unpublished reports covering foods from one's own country	2
- Scientific articles or unpublished reports with insufficient information - Analytical data received from manufacturers without documentation	4
- Original analytical results generated for food composition purposes with good food and component description, good sample plan, quality assurance, etc.	1
- Food composition databases from other countries with limited documentation in the introduction	5
- Books on nutrition (generally with global citation of reference) - Food labels	6

For your information:
Food composition data collected and analysed for food composition purposes are of the highest quality, especially if the sampling and analytical work include data of frequently consumed foods according to the consumption pattern in one's own country and is carried out in accordance with high standards. Food composition data from scientific literature are not necessarily the most appropriate, as they can be analysed to test a method or originate from a different country.

For advanced learners
VII.Q4 In many countries, manufactured products constitute a large part of the diet. It would therefore be desirable that the nutrient values of these foods be included in food composition tables. Indicate how nutrient values can be obtained from manufactured foods. Select True or False. *(3 points: ½ point for each correct response)*

Answer:

How to obtain nutrient values of manufactured foods	True	False
Manufacturers are eager to share the compositional data of their products and normally send them with the full documentation of sampling and analytical methods.		x
The easiest way to collect compositional data is to copy them from the label. However, these data are often calculated using food composition databases and it is not always possible for the compiler to obtain metadata from the manufacturer for the few nutrients on the label.	x	
With some software packages, it is possible to make a rough calculation of nutrient values of manufactured foods based on the list of ingredients and the nutrient values on the label. The calculation is easier and more precise if the quantities of the ingredients are provided.	x	
In most countries, central databases exist with food composition data on manufactured foods sold in the country, including their quantities.		x
Many large companies have websites that include nutrient data on their products.	x	
Food composition data can always be copied from manufactured foods of other countries as formulation of the same product is always the same across countries.		x

For your information:
The same brand name food may have different compositions across countries. This is especially so with regard to fortification, because legislation on this issue may be different across countries. As a general rule, collecting compositional data from manufacturers is a time-consuming and frustrating exercise, and is even more difficult when metadata are involved. However, in some countries, manufacturers are more cooperative and more easily furnish compositional data. It is easy to collect compositional data from the Internet or from food labels, but their quality is, by definition, low because in most cases no documentation is available. In addition, the vitamin content appearing on the label must still be valid at the end of the product's shelf-life. Therefore, more vitamins than those declared on the label are initially included in the product.

In the United States, the NLEA (1990)[25] allows for some nutrients (Class II vitamin, mineral, protein, total carbohydrate, dietary fibre, other carbohydrate, polyunsaturated or monounsaturated fat, or potassium) to be at least equal to 80% of the value declared in the label, and for other nutrients to be less than 20% in excess (e.g. food with a label declaration of calories, sugars, total fat, saturated fat, *trans* fat, cholesterol or sodium). Reasonable excesses over labelled amounts are acceptable within current good manufacturing practices for vitamins, minerals, protein, total carbohydrate, dietary fibre, other carbohydrate, polyunsaturated or mono-unsaturated fat or potassium.

[25] http://www.cfsan.fda.gov/~lrd/CFR101-9.HTML

SAMPLE ANSWERS TO THE EXERCISES[26]

VII.E1 Read the Guide for Authors of the Journal of Food Composition and Analysis (available at: http://www.elsevier.com/wps/find/journaldescription.cws_home/622878/authorinstructions#) and answer the following questions. If indicated, strike through the incorrect answer(s). *(33 points: 1 point for each correct response)*

Answer:

Questions	Responses
Authors' responsibilities (2 points)	Article has not been published previously and it is not under consideration for publication elsewhere
Publishing language (1 point)	English (American or British – but no mix)
Names of chemicals (1 point)	Generic names of chemicals whenever possible
Representation of number (2 points)	• Decimal places (not commas) • Appropriate number of significant digits
Unit of components in general and of energy in particular (2 points)	• International System of Units (SI, Système International d'Unités) or the SI-derived system • Energy: kJ or MJ (equivalent kcal or Mcal may be given in parentheses)
Reporting of calculations (1 point)	Report all components and factors used in aggregations and calculations
List two components that are discouraged (2 points)	• "Total carbohydrate by difference" is not acceptable in results or in tables; however, it may be used in the discussion • "Crude fibre" (as it has no significance in human nutrition)
Format and length of article (2 points)	• Preferable to use type font Times Roman (size 12), with 2.5 cm (1 inch) margins on all sides; use double spacing and one column. Automatic line numbering should be activated • Manuscripts (excluding tables and figures) should not exceed 20 double-spaced pages.
Abstract: list two objectives (2 points)	1. Briefly summarize major findings and conclusions 2. Comprehensible without the rest of the paper
Keywords: minimum number and objective (2 points)	• **Minimum number**: of 6-10 keywords • **Objective:** is to allow the article to be found by Internet database search engines and to considerably increase article citations
Introduction: list two objectives (2 points)	• Briefly review important publications on the topic • State the reasons for the article
Material and methods: list two elements described in this section (2 points)	Your answer should include any two of the following: • sampling protocols, sample handling/preparation, and all experimental conditions and procedures (including quality control/quality assurance procedures), with sufficient clarity to permit qualified researchers to repeat the work; • number/size of samples collected, prepared and extracted, as well as number of analytical replicates per sample; • the statistical procedures/programmes used to assess the work should be cited.
Results: list two elements described in this section (2 points)	1. Data to the appropriate number of significant digits for precision and instrumental sensitivity 2. Statistical interpretation

[26] Individual correct answers may vary.

Questions	Responses
Special reporting requirement for study results using (and citing) food composition databases (1 point)	Cite and reference the database and/or software product with name, version number, release date and vendor
Conclusion: list two elements described here (2 points)	• Summary of important and novel aspects • Suggestions for future research/work
Citation: from each pair, select correct response. ~~Strike through incorrect one~~ (2 points)	**Order of references in text**: chronologically ~~or alphabetically~~ **In final publication, citations "submitted"** are ~~allowed or~~ not allowed
List of references/reference style: from each pair, select correct response. ~~Strike through incorrect one~~ (2 points)	**Name:** ~~O. P. Miller~~ or Miller, O. P. **Year of publication**: in parentheses after authors ~~or at end after comma~~ **Journal name**: ~~abbreviated~~ or full name **Special information for book**: cite editor(s), publisher name/city/country or ~~cite publisher name/city/country~~
Number of peer reviewers (1 point)	At least two
List two rejection criteria for the manuscript (2 points)	Your answer should include any two of the following: 1. topic outside the scope of the journal; 2. lacking technical merit; 3. fragmentary and provides marginally incremental results; 4. is poorly written or 5. is not innovative, or closely duplicates research previously published by the author; 6. only one or two individual food samples per food were analysed (not counting replicates)

VII.E2 Indicate the answer to the following questions. Consult the list of resources at the beginning of this module. If indicated, strike through the incorrect answer(s). *(11 points: 1 point for each correct response)*

Answer:

Questions	Responses
Indicate the resource where retention and yield factors are reported, as used in Europe (1 point)	Bell *et al.*, 2006. *Report on Nutrient Losses and Gains Factors Used in European Food Composition Databases.* (D1.5.5) Available at http://www.eurofir.org/eurofir/Downloads/RecipeCalculation/Bell%20et%20al.%20%20-%20%20Report%20on%20Nutrient%20Losses%20and%20Gains%20Factors%20used%20in%20European%20Food%20Composition%20Databases.pdf
What is the range of nutrient retention factors for vitamin C in boiled potatoes in Europe? See Bell *et al.*, 2006 (1 point)	Range: 15-75 vitamin C loss in potatoes
Which nutrient retention factor is proposed by EuroFIR for vitamin C in boiled potatoes? See Vásquez-Caicedo *et al.*, 2007 (1 point)	70
Which recipe calculation system is proposed for Europe by EuroFIR? ~~Strike through incorrect one(s)~~ (2 points)	**Yield factor to be applied**: ~~at ingredient level or~~ at recipe level ~~or not at all~~ **Nutrient retention factors to be applied**: at ingredient level ~~or at recipe level or not at all~~ (p. 5 of http://www.eurofir.org/eurofir/Downloads/RecipeCalculation/D2.2.9.pdf)
Name two websites where links are found to published food composition tables and databases from the entire world (2 points)	• http://www.fao.org/infoods/directory_en.stm • http://www.langual.org/langual_linkcategory.asp?CategoryID=4&Category=Food+Composition

continued table

Questions	Responses
List two scientific journals that frequently contain food composition data (no web link) (2 points)	Your answer should include any two of the following: • Journal of Food Composition and Analysis • Food Chemistry • Journal of Agricultural and Food Chemistry • Journal of Nutrition • American Journal of Clinical Nutrition • Journal of the Science of Food and Agriculture • European Journal of Clinical Nutrition • British Journal of Nutrition • Journal of Dairy Science • Journal of Food Science and Technology • The Journal of Dairy Research • Horticultural Science • African Crop Science Journal • Potato research • Cereal Sciences
Indicate the website where you can find data on heavy metal contamination of foods for France (1 point)	http://www.afssa.fr/Documents/RapportEAT1EN.pdf
List one database on bioactive components being accessible to the general public without password (1 point)	The USDA databases on isoflavones, flavonoids, cholines and proanthocyanidin (http://www.ars.usda.gov/Services/docs.htm?docid=6382)

GENERAL FEEDBACK USING SELF-SCORING

41 – 55 points: You have understood and integrated the issues concerning 'Resources concerning food composition, and publication of food composition information'. Congratulations. You are well prepared to proceed to the next module and to apply the new knowledge.

27 – 40 points: You have understood and integrated most issues concerning 'Resources concerning food composition, and publication of food composition information'. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so before being able to apply the new knowledge.

14 – 26 points: You have understood and integrated a fair part of issues concerning 'Resources concerning food composition, and publication of food composition information'. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so before being able to apply the new knowledge.

0 – 13 points: It seems there are significant gaps in your understanding of issues concerning 'Resources concerning food composition, and publication of food composition information'. You should read the sections again and improve your knowledge of these topics before being able to apply the new knowledge.

Module 8

RECIPE AND OTHER CALCULATIONS

LEARNING OBJECTIVES

By the end of this module the student will:
- understand the principles of recipe calculation and know how to calculate them;
- understand the influence of yield and nutrient retention factors, and know how to apply them when calculating recipes;
- be able to present recipes and their metadata in reference and user databases[29];
- know how to complete missing values.

REQUIRED READING

- **Charrondière, U.R**. Recipe and other calculations. PowerPoint Presentation. Available at: ftp://ftp.fao.org/es/esn/infoods/Recipecalculation.pdf

and if possible:

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use*. FAO, Rome. Chapters 1 (pp. 7-9), 10 (p.181), 11 (pp. 191-192) and appendix 6 (p. 225)[30]. Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf
- **Rand, W.M., Pennington, J.A.T., Murphy, S.P. & Klensin, J.C.** 1991. *Compiling Data for Food Composition Data Bases*. United Nations University, Tokyo. Sections 4-6 (Data from other sources, Estimation from data on similar foods; Calculation for multi-ingredient foods) pp. 30-62 in the PDF file. Available at http://www.unu.edu/unupress/unupbooks/80772e/80772E00.htm or PFD file at ftp://ftp.fao.org/es/esn/infoods/Randeal1991CompFCDBases.pdf

EXERCISE MATERIAL

- FAO/INFOODS Compilation Tool version 1.2.1[31], an Excel file available at http://www.fao.org/infoods/software_en.stm

RECOMMENDATION

It may be helpful to complete modules 2 (Use of food composition data), 3 (Selection and nomenclature of foods in food composition databases) and 4.b (Component nomenclature) before starting on the present module.

RESOURCES

<u>Yield and retention factors, and recipe calculation</u>

- EuroFIR website on recipe calculation, including yield and retention factors. Available at: http://www.eurofir.org/eurofir/RecipeCalculation.asp :
    - **Bell *et al.*** 2006. *Report on Nutrient Losses and Gains Factors Used in European Food Composition Databases* (D1.5.5).
    - **Vásquez-Caicedo, A.L, Bell, S. & Hartmann, B.** April 2007. *Report on collection of rules on use of recipe calculation procedures, including the use of yield and retention factors for imputing nutrient values for composite foods* (D2.2.9).
    - **Reinivuo, H. & Laitinen, K.** April 2007. WP2.2 *Composite Foods: Harmonisation of Recipe Calculation Procedures* (D2.2.12/M2.2.4)

[29] For an explanation of these terms, see pp. 10-12 of Greenfield & Southgate (2003).

[30] The page numbers indicated correspond to the page numbers of the book (top of the page), and not to those of the PDF file.

[31] This Excel file was developed by FAO/INFOODS and is freely available at the INFOODS website. Users are invited to change the nutrient retention factors according to their needs and to add more factors if they need them. When changing factors or adding lines, care should be taken that the formulas continue to point to the right cells and it should be borne in mind that nutrient values of recipes already calculated might change.

    - **Reinivuo, H** May 2007. *Inventory of recipe calculation documentations of EuroFIR partners*. An annex to the report 'Proposal for the harmonisation of recipe calculation procedures' (D2.2.12/M2.2.4)
- **Bergström, L.** 1994. *Nutrient Losses and Gains*. Statens Livsmedelsverk, Uppsala. Available at http://www.slv.se/upload/dokument/rapporter/mat_naring/1994_32_Livsmedelsverket_nutrient_losses_and_gains.pdf
- **Bognár, A.** 2002. *Tables of weight yield of food and retention factors of food constituents for the calculation of nutrition composition of cooked foods* (dishes). Bundesforschungsanstalt für Ernährung, Karlsruhe. Available at: http://www.bfel.de/cln_045/nn_784780/SharedDocs/Publikationen/Berichte/bfe-r-02-03,templateId=raw,property=publicationFile.pdf/bfe-r-02-03.pdf
- ***McCance & Widdowson's** the Composition of Foods*. 2002. Summary Edition (Sixth Edition). Royal Society of Chemistry. Food Standards Agency, Cambridge, United Kingdom. pp. 431-440.
- **USDA**. 1975. Agriculture Handbook No. 102. *Food Yields Summarized by Different Stages of Preparation*. USDA Agricultural Research Service, Washington, D.C. Available at: http://www.nal.usda.gov/fnic/foodcomp/Data/Classics/ah102.pdf.
- **USDA**. **2003.** *Table of Nutrient Retention Factors, Release 5*. Available at: http://www.nal.usda.gov/fnic/foodcomp/Data/index.html#retention
- **Rodriguez-Amaya, D.B.** 1997. *Carotenoids and Food Preparation: The Retention of Provitamin A Carotenoids in Prepared, Processed, and Stored Foods*. Available at http://www.mostproject.org/PDF/carrots2.pdf
- **Rodriguez-Amaya, D.B.** 1999. *Carotenoides y Preparacion de Alimentos: La Retención de los Carotenoides Provitamina A en Alimentos Preparados, Procesados, Almacenados*. JSI. Available at http://www.inta.cl/latinfoods/TEXTO%20FINAL%20COMPLETO%20CON%20TAPAS%20.pdf
- **JFCA Special Issue**. 2006. After Processing: The Fate of Food Components. *Journal of Food Composition and Analysis* 19 (4): 251-394. Available at: http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%236879%232006%23999809995%23620669%23FLA%23&_cdi=6879&_pubType=J&_auth=y&_acct=C000047720&_version=1&_urlVersion=0&_userid=927244&md5=83c9235f41a18e28b10082c2812db0d7

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts +

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1-2 hours
- Answering the questions: 1-3 hours
- Completing the exercises: 2-5 hours

Answers to the questions

VIII.Q1 Match the terms related to recipes to the corresponding description. *(2.5 points: ½ point for each correct response)*

Terms:
1. Not a recipe
2. Multi-ingredient recipe
3. Single-ingredient recipe
4. Yield factor (YF)
5. Nutrient retention factor (RF)

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

Terms	Description
2	Preparation of different foods together (e.g. vegetable soup)
5	Percentage preservation of nutrients, especially of vitamins and minerals, in a food or dish after storage, preparation, processing, warm holding or reheating
3	Preparation of a food with one ingredient (e.g. boiled potatoes)
1	Food without preparation (e.g. raw apple)
4	Percentage weight change in foods or recipes due to cooking

VIII.Q2 For the following recipe, identify the recipe name, an ingredient name and quantity, recipe quantities, preparation method and yield factor. *(3.5 points: ½ point for each correct response)*

White rice, fried
550 g boiled rice
168 g chopped onions
30 g vegetable oil
21 g garlic
2 g salt
1 g spices

Recipe weight before cooking: 772 g
Fry onions and garlic, add rice and season the food.
Weight loss: 5.6%

Answer:

	Corresponding element in above recipe
Main ingredient name	Boiled rice
Main ingredient quantity	550 g
Preparation method for the recipe	Fry onions and garlic, add rice and season the food
Yield factor	0.944
Recipe name	White rice, fried
Recipe weight before cooking	772 g
Recipe weight after cooking	729 g (=772 x 0.944)

VIII.Q3 Select the least-effective means of collecting recipe information and ingredients. *(1 point)*

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

	Least-effective way to collect recipe information and ingredients
	Recipe books
	Focal group discussions, especially in developing countries
x	Own preferred recipe
	Internet
	Quantitative list of ingredients on the label/from manufacturer

VIII.Q4 Determine the correct order of steps for creating and calculating nutrient values of recipes for a food composition table or database, 1 being the first step and 5 the last. *(2.5 points: ½ point for each correct response)*

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

Order	Steps for creating and calculating nutrient values for recipes
2	Make sure all ingredients have a complete set of nutrient values (no missing data)
5	Include in the user database: (1) a recipe catalogue listing for each recipe, the ingredients and their quantities, a short description of the preparation, and the yield factor used; (2) a list of nutrient retention factors (per food or food group)
1	- Select recipes to be included in the food composition table and database - Collect recipes, and list all ingredients and their quantities and the preparation method - Transform all ingredient quantities into gram edible portion - Collect and/or analyse yield and nutrient retention factors - Decide on recipe calculation system; enter all yield and nutrient retention factors necessary
4	Check results of recipe calculation and copy them into the reference databases
3	- Run the calculation programme - Document data (source of recipes and of yield and nutrient retention factors; recipe calculation system)

VIII.Q5 In many recipe books, the ingredients are not listed in grams but in units (e.g. one onion, two tablespoons of oil, half a cup of flour). Select the correct response to indicate how ideally, if not already existing for the country, weights of units and edible coefficients of ingredients should be obtained. *(1 point)*

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

	Weight of units and edible coefficients of ingredients should be obtained as follows:
	copy them from other national databases (e.g. USDA) because they are the same in most countries.
x	sample (e.g. ten) food samples of each ingredient, weigh them with and without inedible part, record the dimensions and calculate the average weight and edible coefficient.
	estimate them based on own judgment.

For your information:
Weights of units are different across countries because of different dimensions of foods or household measurements. Copying the weight of foods from other countries should be avoided as it may introduce major errors into the nutrient values of recipe and in other calculations (e.g. nutrient intake estimations).

It would be useful to publish the weight and dimensions of measured foods in national food composition tables and databases. This might be helpful for food consumption surveys.

VIII.Q6 Recipes can be calculated using different methods, depending if and where yield and nutrient retention factors are applied. Factors can be applied at ingredient level (i.e. to the nutrient values of each ingredient) or recipe level (i.e. after summing the nutrient values of all ingredients). Match the method to the corresponding concept or definition. *(2 points: ½ point for each correct response)*

Methods:
1. Raw ingredient method, i.e. summing nutrient values of raw ingredients without applying any factors;
2. Ingredient method, i.e. yield and nutrient retention factors are applied at ingredient level;
3. Recipe method, i.e. yield and nutrient retention factors are applied at recipe level;
4. Mixed method, i.e. yield factor is applied at recipe level and nutrient retention factors at ingredient level.

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

	Corresponding definition and concept
4	Ingredient 1: NV x RF Ingredient 2: NV x RF Ingredient 3: NV x RF --- Recipe: Sum of above x 1/YF
1	Ingredient 1: NV Ingredient 2: NV Ingredient 3: NV -- Recipe: Sum of above
3	Ingredient 1: NV Ingredient 2: NV Ingredient 3: NV -- Recipe: Sum of above x 1/YF x RF
2	Ingredient 1: NV x 1/YF x RF Ingredient 2: NV x 1/YF x RF Ingredient 3: NV x 1/YF x RF --- Recipe: Sum of above

NV= nutrient values, YF = yield factor, RF = nutrient retention factor

For your information:
Most countries use the mixed method, e.g. EuroFIR partners. Up until their 5th edition, the British food composition tables by McCance and Widdowson used the recipe method but have been using the mixed method since the 6th edition. The disadvantage of the recipe method is that it is not always easy to decide on the main ingredient which determines the food category to which the recipe belongs and, consequently, which set of nutrient retention factor is applied to the entire recipe.

The raw ingredient method is not recommended except for raw dishes, e.g. fruit salad.

VIII.Q7 Indicate the correct response(s) to show whether nutrient retention factors exist for all foods, recipes and food/recipe groups. Select True or False. *(2 points: ½ point for each correct response)*

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

Nutrient retention factors exist for:	True	False
all food groups	x	
all foods and ingredients		x
all recipes		x
all recipe groups	x	

For your information:
Nutrient retention factors exist for all common food and recipe groups but do not exist for all individual foods and recipes (only for some). When nutrient retention factors exist for individual foods, they should be used, and when they do not exist for a specific food, the nutrient retention factors of the relevant food (sub) group should be applied. In order to apply nutrient retention factors in a harmonized way, the foods should be in the same food group across countries and a common decision tree on the choice of nutrient retention factors should be applied. An overview of the different nutrient retention factors is given in Bell *et al.* (2006).

VIII.Q8 How should yield and nutrient retention factors ideally be obtained? Determine the correct order of the responses to obtain high-quality data; 1 being of the highest quality and 4 the lowest. *(2 points: ½ point for each correct response)*

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

Order	Yield and nutrient retention factors can be obtained by:
2	calculating the yield factor of a recipe based on the yield factors of its ingredients, which can only be done if the yield factors of all ingredients are known, or by copying yield factors from the literature while prioritizing factors deriving from similar recipes.
4	estimating them based on own judgment.
1	weighing the food or recipe before and after cooking, and analysing the nutrient content of the recipe before and after cooking.
3	copying factors from more or less similar foods and recipes, with the aim of having a complete set of factors.

VIII.Q9 It may happen that nutrient values are missing for some ingredients. Select the correct response to indicate how to deal with this problem in recipe calculations. *(1 point)*

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

	Dealing with missing nutrient values in ingredients when calculating recipes
	Build the sum of the nutrient values of all ingredients, irrespective of whether values are missing for any of the ingredients.
x	Build the sum of the nutrient values of all ingredients only if there are no missing values for any ingredient, or if a missing value belongs to a minor ingredient, or if the missing value is expected to make only a small nutrient contribution to the recipe.
	Build the sum of the nutrient values of all ingredients, irrespective of whether values are missing for main ingredients.

For your information:
Ideally, no values should be missing for any ingredient. However, as many databases have missing values, this problem does occur and should be dealt with when calculating recipes.

VIII.Q10 In any given country, recipes may be named differently even with the same ingredients; or may have the same name but contain different ingredients depending on the region; or there may be differences in the recipe composition for selected ingredients. Select the correct response to indicate how to deal with this problem. *(1 point)*

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

	Dealing with different names and ingredients for same recipe
	State the same recipe name but change the ingredients.
	Add the altering ingredient to the recipe name and change the ingredients accordingly. It is not necessary to add the region to the name as people will be able to identify the regional-specific recipe through the list of ingredients.
x	Add the varying ingredients and/or region to the recipe name (and probably the synonym name) and change the ingredients accordingly.

VIII.Q11 List four of the possible sources of error in recipe calculations. *(4 points: 1 point for each correct response)*

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

Your answer should include any four of the following:

- indicating inappropriate weight of water as ingredient;
- forgetting to add water to the recipe calculation (e.g. in soups);
- forgetting to add fat for frying to the recipe;
- making an error in transforming the ingredients from units (e.g. one big onion) to gram edible portion, e.g. forgetting to apply edible coefficient to an ingredient (if applicable) or choosing wrong weight of food unit;
- applying nutrient values of ingredients per 100 g and forgetting to adjust for actual weight of ingredients in the recipe (e.g. 150 g);
- using inappropriate yield and retention factors (or worse, not applying them for cooked dishes and foods);
- using different ingredients as in original recipe or same ingredients but in other quantities;
- selecting wrong foods from the database (not corresponding to ingredients).

VIII.Q12 The nutrient values of recipes can be either calculated or analysed. It is very expensive to analyse recipes but their nutrient values are precise. The calculation of nutrient values of recipes is cheap and provides a great deal of flexibility, but results in a lower quality compared with original analytical data. There are other advantages and disadvantages to these approaches. Select from the following statements the reasons why compilers of food composition tables and databases would calculate component values using recipes and other calculation/estimation procedures as opposed to analysing them. Select True or False. *(3 points: ½ point for each correct response)*

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

Reasons why compilers of food composition tables and databases should calculate and estimate component values for recipes	True	False
Recipe calculations are needed because recipes cannot be analysed with a good degree of precision.		x
It is better to have lower quality values (through recipes and estimations) than missing values.	x	
Because the intra- and interpersonal variation in the preparation of recipes is greater than the precision of calculated or analysed nutrient values of recipes, it is appropriate to calculate the nutrient values of recipes consumed by the population.	x	
Most users need data on recipes, especially in countries where recipes represent a high proportion of the total food intake. Compilers can make these calculations more easily and normally at a higher quality than the users. Therefore, it would be preferable to publish calculated recipes in food composition tables and databases.	x	
Recipe calculation methods are also used to calculate the nutrient composition of cooked foods (i.e. single-ingredient recipe calculation). But as the nutrient composition of cooked foods is the same as that of raw foods, there is no need to calculate the nutrient values of cooked foods.		x
Missing nutrient values (e.g. missing vitamin C value of a fruit stew) are not important because they do not influence nutrient intake estimations. All missing values can be estimated as zero.		x

For your information:
Because the intra- and interpersonal variation in the preparation of recipes is greater than the precision of calculated or analysed nutrient values of recipes, it is more cost-effective to calculate the nutrient values of recipes than to analyse them.

Users often treat missing values as zero values, which results in an underestimation of nutrient intake (see module 2).

The different cooking methods change nutrient composition differently.

VIII.Q13 In the following text, strike through the options that are incorrect. *(4.5 points: ½ point for each correct response)*

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

Recipes are analysed because these data are of ~~low~~/high quality. The disadvantages when analysing a recipe are: (1) that in the analysed recipe, all ingredients and their quantities are fixed/~~flexible~~ i.e. no/~~some~~ ingredients can be changed without introducing changes in at least one of the analysed nutrient values; and (2) the preparation of the recipe often represents its preparation by one ~~population/~~person. The nutrient values of a recipe ~~can~~/cannot be calculated from a similar recipe that has been analysed. Recipes are ~~little~~/highly variable in their composition of ingredients, depending on preferences and the availability of ingredients. The analysed nutrient values for a recipe are only applicable to the fixed quantity of all/~~some~~ ingredients in the analysed recipe, which means that the analysis of recipes is ~~cost-effective~~/not cost-effective. It is more/~~less~~ cost-effective to analyse the raw ingredients of the recipes and then calculate the different recipes based on the analysed ingredients, rather than analysing each recipe separately.

VIII.Q14 Data are missing in most food composition tables and databases. Match the correct expressions to the corresponding definition. *(2 points: ½ point for each correct response)*

Expressions:
1. Missing value
2. Missing food
3. Missing nutrient
4. Missing documentation

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

	Corresponding definitions
3	A nutrient is missing for all foods.
1	A value is missing for a food, (e.g. nutrient value, edible (or refuse) value, density value).
4	Metadata are not available to explain the value.
2	The food or recipe and its nutrient values are not reported.

VIII.Q15 List three approaches to complete missing values in a food composition database. *(3 points: 1 point for each correct response)*

Answer (see Rand *et al.*, 1991 and PowerPoint presentation of Charrondiere on Recipe and other calculations):

Your answer should include any three of the following approaches to complete missing values:

- analyse foods;
- estimate value(s) from a similar food within one's own food composition database or from other sources;
- calculate missing value(s) through recipe calculation or other standard procedures;
- presume value(s), for example, as zero (if the food is known not to contain the nutrient, e.g. vitamin C in oil);
- copy values from other sources.

For your information:
Whatever method is used to complete missing data, it should be documented in the database.

VIII.Q16 List four of the possible ways of checking that the food from another source is the same as, or at least the most similar to, the foods in one's own database. Do the same for nutrients. *(8 points: 1 point for each correct response)*

Answer (see Rand *et al.*, 1991, PowerPoint presentation of Charrondiere on Recipe and other calculations):

Check that it is the same food (or the most similar)

Your answer should include any four of the following:
- check the food name, including taxonomic name (species and variety);
- check that the meat cut is really the same part of the animal (different countries have different names for the same meat cuts);
- check that the food description is equivalent;
- check that fat, water and protein content are the same or similar (if not, some nutrient values need to be adjusted) and in specific cases check also other nutrients, e.g. carotenes;
- check composition of brand name foods (especially across countries and time);
- check whether the food is fortified.

Check whether the nutrient is the same

Your answer should include any four of the following (see module 4.b, 4.c and 4.d for more information):
- check whether the nutrient definition is comparable, e.g. equivalents have the same conversion factors and the same contributing nutrients;
- check whether different analytical methods exist for the same component and whether they provide comparable results (same tagname);
- check whether the expressions are the same, e.g. available carbohydrates in monosaccharide equivalent vs. available carbohydrates as weight;
- check whether sums contain the same nutrients, e.g. the sum of saturated fatty acids – check which fatty acids are included in the sum, and if cis and *trans* are included or only cis;
- check whether the units and denominators are the same.

VIII.Q17 When copying nutrient values from other sources, it is recommended that you verify that the contents of water, fat and protein are the same, or similar, between the food in one's own database and the food of the other source from which the values will be copied. Often, if there are significant differences (e.g. more than 10%), the values are adapted before incorporating them in one's own database. Match the nutrients that need to be adapted to the corresponding nutrient with significant differences in content between the foods. *(1.5 points: ½ point for each correct response)*

Nutrient with significant differences:
1. Significant difference in fat content
2. Significant difference in water content
3. Significant difference in protein content

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

	Adapt the nutrient values of the following nutrients accordingly
2	Water soluble vitamins and minerals
1	Fatty acids, fatty acid fractions, fat soluble vitamins, cholesterol
3	Amino acids

VIII.Q18 For each of the following vitamins, indicate whether they depend on the fat or water content of the food. *(3 points: ½ point for each correct response)*

Answer (see module 4.d):

Vitamin	Depend on water value	Depend on fat value
A		x
B	x	
C	x	
D		x
E		x
K		x

VIII.Q19 Match the following calculations to the corresponding formula. *(2.5 points: ½ point for each correct response)*

Calculations:
1. Calculate the nutrient value of vitamin C in boiled potato, based on raw potato;
2. Calculate water content of recipe;
3. Impute fatty acid value and adapt to the difference in fat content between source and own food (e.g. difference > 10%);
4. Impute nutrient value on dry matter basis and adapt to difference in water content between source and own food (e.g. difference > 10%);
5. Impute nutrient value on non-fat solid basis (also called 'fat-free dry matter' basis).

Answer (see PowerPoint presentation of Charrondiere on Recipe and other calculations):

	Corresponding formula
5	$= \frac{\text{NV (SF) x (100 – water (OF) – fat (OF))}}{\text{100 – water (SF) – fat (SF)}}$
2	[water value of raw food or recipe-(a-b)/b] x 100 where a = raw weight and b = cooked weight
4	NV (SF) x (100 – water (OF)) / (100 – water (SF))
1	NV of raw food or recipe x 1/YF x RF
3	NV (SF) x fat (OF) /fat (SF)

NV= nutrient values, YF = yield factor, RF = nutrient retention factor, SF = source food, i.e. food from which NV are copied, OF = own food, i.e. food in own database to which NV are copied

For your information:
Fat-free dry matter (non-fat solid basis) calculations are done by USDA for components not depending on fat content. This calculation is also used in the literature as the basis to express the concentration of minerals or to determine the protein-ash ratio or to determine the quality of a food (e.g. whole milk should have 8.5% fat-free dry matter).

VIII.Q20 Match the foods to the corresponding method to calculate or estimate the missing nutrient values. *(5.5 points: ½ point for each correct response)*

Missing foods:
1. Chicken drumstick with skin, raw
2. Pork, chop with visible fat, raw
3. Pork, chop with visible fat, grilled
4. Beef stew
5. Yoghurt, sheep's milk, skimmed, plain
6. Yoghurt, cows' milk, sweetened, plain, whole
7. Cheese, hard, 30% fat, cow's milk
8. Dried mango
9. Mixed fruit salad
10. Banana, raw (as purchased, i.e. including inedible portion)
11. Cornflakes, fortified

Answer:

How to calculate or estimate the missing nutrient values	
Measure lean meat and visible fat and build a recipe with these two ingredients according to the measured proportion. The nutrient values for raw lean pork meat and raw pork fat can be either taken from analytical work or copied from other sources.	2
Take the nutrient values of unfortified cornflakes and replace the values of the fortified nutrients with the values indicated on the label.	11
Take the nutrient values of whole plain yoghurt and add sugar according to the label information on the sugar and carbohydrate value, and recalculate energy (check that both are from cow's milk).	6
Weigh dark meat and skin and build a recipe with these two ingredients according to the measured proportion. The nutrient values for raw dark meat and raw skin can be either taken from analytical work or copied from other sources.	1
Take the nutrient values of raw banana (edible portion) and apply the edible portion coefficient to all values.	10
Take the nutrient values of hard cheese with 45% fat and adapt both the fat content and the fat soluble vitamins and cholesterol accordingly (check that both are from cow's milk).	7
Take nutrient values of whole plain yoghurt and adapt both the fat content and the fat soluble vitamins and cholesterol accordingly (check that both are from sheep's milk).	5
Take the nutrient values of 'Pork, chop with visible fat, raw' and apply a recipe calculation. Select the appropriate nutrient retention factor either for the specific food or for pork or for meat (depending on the availability of data), and measure or estimate the yield factor.	3
Select a recipe (e.g. from a standard recipe book), verify that all ingredients are listed (especially water and fat for frying), transform the ingredient quantity into weight, select foods with complete nutrient values from the database, select appropriate yield and nutrient retention factors, and apply recipe calculation system.	4
Select a recipe (e.g. from a standard recipe book), transform the ingredient quantity into edible weight, select foods with complete nutrient values from the database, sum the ingredients and bring the nutrient values to per 100 g.	9
Take the nutrient values of raw mango, measure the water content of the dry mango, and adapt all nutrient values to the difference in water content (check that the raw mango is similar to the dried mango, especially in colour, as the carotene content changes significantly with different colours).	8

VIII.Q21 For the following nutrients, indicate whether missing values can be estimated from other nutrients in the same food. Select Yes or No. If Yes is selected, indicate how it can be estimated. *(4 points: ½ point for each correct response)*

Answer (see Rand *et al.*, 1991, pp. 21, 25):

Nutrient	Can be estimated Yes/No	How to estimate
Available carbohydrates	Yes	100 g minus total grams of water, protein, fat, alcohol, ash and dietary fibre; or CHOCDF minus dietary fibre
Tryptophan contribution for niacin equivalent	Yes	1% of protein value
Retinol	No	-
Calcium	No	-

SAMPLE ANSWERS TO THE EXERCISES

VIII.E1 A food consumption survey was carried out in South Africa and the recipe 'omelette with onions and tomatoes' was reported. The ingredients and their quantities were taken from a standard recipe book. Transform the ingredient quantities into gram edible portions of the recipe and round the weights so that they end with 0 or 5 g. For example, 111.5 g butter to be rounded down to 110 g. *(5 points: 1 point for each correct response)*

Available data:
1 extra large egg = 58 g (USDA)
1 small egg = 38 g (USDA)
1 egg = 50 g (McCance and Widdowson's tables – United Kingdom)
1 egg = 45 g (measured in South Africa)
1 cup of chopped onions = 160 g (USDA)
1 onion = 170 g (South Africa)
1 large tomato = 182 g (USDA)
1 medium tomato = 123 g (USDA)
1 small tomato = 91 g (USDA)
1 medium tomato = 100 g (South Africa)
1 small tomato = 80 g (South Africa)
1 tablespoon = 15 mL (own measurement)
1 teaspoon = 5 mL (own measurement)
Density of milk = 1.03g/mL (McCance and Widdowson's tables – United Kingdom)
Density of butter = 0.96g/mL (own measurement)
Edible coefficient of onion = 0.9 (own measurement)
Edible coefficient of egg = 0.95 (own measurement)
Edible coefficient of tomato = 0.91 (own measurement)

Volume in mL x density factor = weight in g

Answer:

'Omelette with onions and tomatoes', with the ingredients shown in the recipe book	Ingredient weight in edible portion
2 eggs	2 x 45 x 0.95 = 85.5 rounded to 85
2 tablespoons milk	2 x 15 x 1.03 = 30.9 rounded to 30
1 teaspoon butter	5 x 0.96 = 4.8 rounded to 5
1 large onion	170 x 0.9 = 153 rounded to 155
2 small tomatoes	2 x 80 x 0.91 = 145.6 rounded to 150

For your information:
It is better to take the weights of foods from one's own country. If they are not available, it is preferable to measure them instead of using the weights of another country.

VIII.E2 Answer the following questions. *(7 points: 1 point for each correct response)*

Answer:

Questions	Responses
A raw steak of 200 g is fried and thereafter has a weight of 150 g. How much is the yield factor?	0.75 (= 150/200; that means 25% loss of weight
In the above raw steak, there is 20 g protein per 100 g. How much protein is in fried steak?	30 g (= 2 x 20 g x 0.75)
In 100 g fresh fish, there is 12 g protein and 75 g water. The fish is dried and loses 60 g water. How much protein is in 100 g dried fish?	30 g (= 12 x 100/40)
100 g dried beans have 22 g of protein. How much protein is in 50 g dried beans?	11 g (= 22 x 50/100)
100 g dried beans have 22 g of protein. How much protein is in 100 g of boiled beans when the yield factor is 2.5?	8.8 g (= 1/2.5 x 22)
A compiler compares values per 100 g from different sources. A cereal food in the national database contains 20 g carbohydrate (in available carbohydrates by difference). The same food has 25 g carbohydrates (in total carbohydrates by difference) and 5 g fibre in the USDA tables and 20 g (in monosaccharide equivalents) in the UK tables[30]. Which value is the closest to the national value?	The USDA value, as it is equivalent to 20 g available carbohydrates by difference. (25 g total carbohydrates by difference are equal to 20 g in available carbohydrates by difference after subtraction of 5 g dietary fibre. The United Kingdom value is expressed in monosaccharide equivalents and therefore 10% should be subtracted for starchy foods. This comes to 18 g available carbohydrates by weight, which should be similar to available carbohydrates by difference)
A maize porridge has 300 g wholemeal maize, 200 g dried cowpeas and 100 g raw onions. Boil all ingredients. Which main ingredient is missing?	Water

VIII.E3 Calculate the nutrient values of boiled tomatoes based on raw tomato. Use the Compilation Tool version 1.2.1 and calculate the nutrient values of the cooked food by following the instructions below. Then copy the results of the calculation found in the different cells in the Compilation Tool into the corresponding answer in the table below. *(15 points: 1 point for each correct response)*

Note: The Compilation Tool version 1.2.1 is an Excel file available at http://www.fao.org/infoods/software_en.stm . The component names are tagnames. Their meanings and units can be found in the component worksheet (and at http://www.fao.org/infoods/tagnames_en.stm). For those not very familiar with Excel you might find it helpful to consult 'Excel help' available at http://office.microsoft.com/en-us/excel/FX100646951033.aspx . The Excel function described below may be named differently in word vista.

Logical steps to be followed in the recipe calculation:
The most important part of this exercise is that you understand the formulas and the steps and that you will be able to calculate nutrient values of any cooked food based on the corresponding raw food.

1. Insert the line with the raw food and its nutrient values into the recipe calculation spreadsheet (to copy values use PASTE-SPECIAL – not paste).
2. Insert an empty line for the cooked food to record the nutrient values once calculated.
3. Look at the formulas of the example of boiled rice and try to understand the formulas
4. Copy the formulas to calculate the nutrient values from the example (to copy formulas use PASTE – not paste-special).

30 Total carbohydrates by difference – dietary fibre = available carbohydrates by difference.
Carbohydrates in monosaccharide equivalents /1.1 = available carbohydrates by weight.

5. Adapt the formula to calculate the nutrient values to point to the correct yield and nutrient retention factors and the correct cells containing the nutrient value of the raw food (in this case of raw tomato) and copy the adapted formula to all values except for WATER and XN.
6. Check that you have made the calculation correctly and that no 0 value was generated by accident (if no value exists for raw tomato and the formula is entered, Excel will generate a 0 value for cooked tomato).
7. Copy the newly-generated nutrient values to the inserted line (see step 2) for boiled tomato (with PASTE-SPECIAL) and then copy the line from the recipe calculation spreadsheet to the reference database spreadsheet where you also should document the new values.

Specific instructions for the Excel file exercise:
Please remember that working with Excel calls for a very careful work – any error in a formula or in copying and pasting (paste-special for values or paste for formulas) or inserting results in wrong calculations. Therefore, always check that formulas point to the appropriate cells and think before using 'paste', 'paste special' or 'insert' if this is the correct function you need to apply.

1. Copy line 21 (tomato, ripe, raw – final record) from the worksheet 'reference database' and paste it into the worksheet 'recipe calculations' at line 120. Use the function PASTE SPECIAL – VALUES.
2. Copy line 23 (tomato, boiled) from the worksheet 'reference database' and paste it into the worksheet 'recipe calculations' into line 119.

Then in worksheet 'recipe calculation' do the following:

1. Copy lines 37-40 into lines 121-124 (i.e. copy all formulas for single-ingredient recipe calculation from the example of boiled rice to calculate the nutrient values of boiled tomato based on raw tomato).
2. Put 100 (for 100 g) into cell E120 and 1 for edible factor for boiled tomato (cell Q123) as boiled tomato is 100% edible.
3. Enter the yield factor of 0.8 (Bergström, 1994) into E122 and the system will calculate the cooked weight (see change in cell E121 – the cooked weight becomes 80 g, calculated from 100 g raw tomato by applying the yield factor of 0.8).
4. Now, you need to adjust the formula so that it points to the nutrient retention factor for boiled vegetables and to the yield factor of boiled tomato. Change the formula in the first nutrient (ENERC-kJ original) in cell R123. The formula should read: =R120*1/$E$122*R63 (Do not forget = at the beginning of the formula, if not the system does not recognize that the cell contains a formula.)
5. **Except for WATER and XN** copy this formula to all cells in line 123 **which have a nutrient value in line 120** (if you copy the formula to a cell which does not have a nutrient value in raw tomato you would create a zero value for boiled tomato. This would be a major error. So care should be taken to avoid creating zero values for boiled tomato). For XN, take the same value as in the raw food (XN does not change with cooking), and for WATER there is a special formula.
6. The system automatically calculates the water content for 100 g of cooked dish based on the entered formula.
7. Check that you have calculated a nutrient value for boiled tomato only if there was a value in line 120 of raw tomato (delete the 0 if there were no values in the line of raw tomato - if not you are creating zero values for missing values which, as said before, would be a major error!!).
8. Copy with PASTE SPECIAL - VALUE (if you do just PASTE you would copy the formulas) the nutrient values of line 123 into line 119 of 100 g 'Tomato, boiled' and then copy the entire line 119 into the worksheet 'reference database' into line 23 of boiled tomato.

Congratulations

Now verify that you have made the calculation correctly by answering the following questions. Please copy the numbers or formulas from the Compilation Tool into the corresponding answer.

Answer:

Questions	Responses (copy the corresponding figure or formula from the Compilation Tool)
Cooked weight	80
Formula to calculate water (in cell V123)	=(V120-(E120-E121))/(E121)*100
Chosen food category for nutrient retention factors	VEGETABLE AND VEGETABLES PRODUCTS including legumes - retention factors boiling
Formula to calculate fat content (FAT standardized) of boiled tomato is =AB120*1/$E$122*AB63. What is $E$122?	The yield factor of boiled tomato
Values of boiled tomato	------------
• **Edible coefficient**	1
• **XN (two decimal places)**	6.25
• **Water (one decimal place)**	91.2
• **Standardized fat (two decimal places)**	0.42
• **Standardized carbohydrates (two decimal places)**	4.33
• **Standardized dietary fibre (two decimal places)**	2.25
• **Standardized vitamin A (two decimal places)**	103.33
• **Riboflavin (three decimal places)**	0.018
• **Fatty acid 4:0, undifferentiated (two decimal places)**	no value
• **Lysine (two decimal places)**	48.75
Would the calculated nutrient values be different if the ingredient or recipe method would be applied? Select yes or no.	No, because it is a single-ingredient recipe calculation and yield and retention factors are applied to the food (which is ingredient and sum of ingredients at the same time).

For your information:
It is possible to check whether any calculation errors have been made. For example, if the yield factor is 0.8, the nutrient values of boiled tomato should be roughly 20% higher than those of raw tomato. For nutrients with nutrient retention factors, the difference will be smaller.

It might take one hour to do a recipe calculation for the first time. After some experience it will take much less time (about 20 minutes) to calculate one recipe. Keep going!

VIII.E4 Calculate the nutrient values of the recipe 'Fried rice with tomato' using the mixed recipe method. Use the Compilation Tool version 1.2.1 and calculate the nutrient values of the recipe by following the instructions below. Then answer the following questions based on the calculations made in the Excel spreadsheet. *(15 points: 1 point for each correct response)*

Fried rice with tomato
200 g boiled white rice
150 g raw tomatoes
30 g margarine

Cooking Instructions: fry the tomatoes with the margarine, add the boiled rice and fry for some minutes.

Water loss: 10%

Logical steps to be followed in the recipe calculation:
The most important part of this exercise is that you understand the formulas and the steps and that you will be able to calculate any nutrient values of any cooked food based on the corresponding raw food.

1. Insert the lines with the raw foods and their nutrient values into the recipe calculation spreadsheet (to copy values use PASTE-SPECIAL – not paste). They have nutrient values per 100 g.
2. Insert an empty line for the recipe to record the nutrient values once calculated.
3. Create for each ingredient a line and adapt the ingredients' nutrient values according to their weight in the recipe. Check that the formulas point to the correct cells.
4. Choose a recipe calculation system (recipe or ingredient or mixed method).
5. Look at the formulas of the recipe example and try to understand the formulas.
6. Copy the formulas to calculate the nutrient values from the example (to copy formulas use PASTE – not paste-special).
7. Adapt the formula to calculate the nutrient values to point to the correct yield and nutrient retention factors and the correct cells containing the nutrient value of the raw foods and copy the adapted formula to all values except for WATER and XN.
8. Check that you have made the calculation correctly and that no 0 value was generated by accident (if no value exists for all ingredients and the formula is entered, Excel will generate a 0 value for recipe).
9. Copy the newly-generated nutrient values to the inserted line (see step 2) for the recipe (with PASTE-SPECIAL) and then copy the line from the recipe calculation spreadsheet to the reference database spreadsheet where you also should document the new values.

<u>Specific instructions for the Excel file exercise</u>:

Please remember that working with Excel calls for a very careful work – any error in a formula or in copying and pasting (paste-special for values or paste for formulas) or inserting results in wrong calculations. Therefore, always check that formulas point to the appropriate cells and think before using 'paste', 'paste special' or 'insert' if this is the correct function you need to apply.

1. In the 'reference database' worksheet, create a new record in line 33: enter the recipe name, the food code 0101015, R for recipe (into cell D33), the record number 1, and the source ('calc. with mixed method'). Then copy this line to the worksheet 'recipe calculation' into line 130.
2. From the worksheet 'reference database', copy lines 8 (Rice, white, short-grain, boiled), 21 (Tomato, ripe, raw – final record), and 25 (Margarine, 80% fat, vegetable fat) and paste them into the worksheet 'recipe calculation' into lines 126, 127 and 128, respectively. Use the function PASTE SPECIAL – VALUES. Put 100 into cells E126-E128 and E130 to indicate that the nutrient values are per 100 g.

Then in the recipe calculation worksheet do the following:

1. Copy lines 126-128 to lines 131-133, respectively.
2. Put the above-mentioned weight of the ingredients into cells E131-E133 (200, 150 and 30 respectively).
3. Except for XN, adapt all nutrient values of the ingredients (lines 131-133) to the ingredient weights in the recipe and to the corresponding nutrient retention factor. For example, in cell R131 put formula =R126*($E$131/100)*R32 (adaptation of nutrient value to different weight of ingredient in recipe, and pointing to nutrient retention factors for baked cereals and cereal products). In cell R132 put formula =R127*($E$132/100)*R64 (pointing to weight of tomato and nutrient retention factors for fried vegetable and vegetable products); and in cell R133 put formula =R128*($E$133/100)*R74 (pointing to weight of margarine and to nutrient retention factors for fried fat and oils). Do not forget to put = in front of the formula and the $ signs in front of E and 131 – if not the formulas do not work. Then copy the formula to all cells where there are nutrient values in the corresponding food with values per 100 g. In this way, the nutrient retention factors are applied at ingredient level.
4. Copy lines 87-91 into lines 134-138 (i.e. to copy the formulas of the mixed recipe calculation method to our recipe).
5. Enter the correct yield factor (0.9) into cell E136 and the system will calculate the cooked weight automatically (if this is not done automatically you have to copy lines 86-90 again and paste them into 130-130; pay attention <u>not to use</u> PASTE SPECIAL – values).
6. Verify that, for the first nutrient, the sum of the nutrient values captures all ingredients of the recipe. For example, in cell R134, the formula should be =SUM(R131:R133). Then copy the formula to all nutrients of the recipe (including water but **excluding XN**).

7. Calculate the nutrient values per 100 g recipe (**except for water and XN**). The formula corresponds to the nutrient values of 100 g cooked dish = (sum raw nutrient values including retention factor/cooked weight) x 100 (e.g. in cell R137, the formula should be =R134/$E$135*100. In this way, the nutrient yield factors are applied at recipe level.
   a. apply the yield factor (YF) to the sum of the nutrient values of the raw ingredients;
   b. adapt the recipe weight to 100 g: divide the sum of nutrient values by the cooked weight of the recipe and multiply by 100 (to come to 100 g recipe);
   c. correct the formula to point to the cooked weight of this recipe ($E$135). The $ signs in front of E and 135 are needed so that Excel always goes to this cell when copying the formula to the remaining nutrients of the recipe.

8. The system automatically calculates the water content for 100 g cooked dish based on the entered formula.
9. Calculate XN by dividing the protein value by the nitrogen value: XN = PROCNT (PROT)/ NT.
10. Check that you have calculated the nutrient values only for those nutrients which have a value in the line of the ingredients with 100 g ingredient (delete the 0 if there were no values in the ingredient - if not, you are creating zero values for all missing values, which would be a major error!!).
11. Enter edible coefficient 1.
12. Copy with PASTE SPECIAL - VALUE (if you do just PASTE, you would copy the formulas) the nutrient values of line 137 (starting edible coefficient) into line 130 of 100 g fried rice with tomato and then copy the entire line 130 into line 33 of the worksheet 'reference database'.
13. To check your calculation enter the formula of the 'sum of proximates (own DB)' (DB stands for database) into cell O33 (copy the formula e.g. from cell O31).

Congratulations

Now verify that you have made the calculation correctly by answering the following questions. Please copy the numbers or formulas from the Compilation Tool into the corresponding answer.

Answer:

Questions	Responses
Cooked weight	342
Formula to calculate XN (in cell W123)	=Y137/X137
Chosen food categories for nutrient retention factors	Nutrient retention factors for baked cereals and cereal products, for fried vegetable and vegetable products and for fried fat and oils
Formula to calculate the standardized fat content of fried rice with tomato	=AB134/$E$135*100
Values of fried rice with tomato	------------------
• **Edible coefficient**	1 (because all ingredients are in edible weight in the recipe, therefore all the recipe is edible)
• **XN (two decimal places**	6.02
• **Water (one decimal place)**	71.0
• **Standardized Fat (two decimal places)**	7.43
• **Standardized carbohydrates (two decimal places)**	17.88
• **Standardized dietary fibre (two decimal places)**	0.94
• **Iron (one decimal place)**	0.4
• **Riboflavin (three decimal places)**	0.014
• **fatty acid 18:1 N-9 (two decimal places)**	2.35
• **Lysine (two decimal places)**	96.70
Would the calculated nutrient values be different if the ingredient or recipe method were applied? Select yes or no	Yes

For your information:
The instructions to carry out the recipe method are slightly different from the mixed method. The main difference is to apply both the nutrient retention and yield factors at the recipe level.

It will take you some time to calculate the nutrient values for the first recipe. With more experience, it will take about 20 minutes to calculate a recipe.

VIII.E5 Impute the calcium and retinol content of 'Low-fat yoghurt, plain' from 'Whole yoghurt, plain', and adapt the imputed values if the difference in fat or water is greater than 10%. Use the formulas of VIII.Q19. *(4 points: 1 point for each correct response)*

Note: Data are per 100 g edible portion

Answer:

	Water in g	Fat in g	Calcium in mg	Retinol in mcg
Whole yoghurt, plain	**81.9**	**3.0**	**200**	**28**
Low-fat yoghurt, plain (calculate by adapting for differences in water or fat content)	**87.2**	**1.0**	200 (same value as difference in water <10%)	9 28 x 1.0/3.0 = 9.33 (rounded to 9)
Low-fat yoghurt, plain (calculate on the basis of fat-free dry matter)	**87.2**	**1.0**	156 200 x (100 -87.2 – 1.0) / 100 – 81.9 – 3.0 = 156.29 (rounded to 156)	Not applicable

For your information:
The values of this example are taken from the 6th edition of McCance and Widdowson's tables. In this table, the calcium and retinol values of 'Low-fat yoghurt, plain' are 162 mg and 8 mcg, respectively.

When adapting for differences in water and fat content over 10%, the calcium and retinol values are similar between the calculated values and those in the British table: 200 vs. 162 mg for calcium and 9 vs. 8 mcg for retinol. If the calcium value were to be adapted for the difference in water content (even though the difference is < 10%) the calcium content would be 187 mg. The values calculated on the basis of fat-free dry matter are also similar. This shows that imputed values can be similar. However, it is better to analyse values.

The calculation on the basis of fat-free dry matter is not applicable to fat-related nutrients.

VIII.E6 When imputing or calculating missing values, a number of decisions have to be taken. For each question, select the most accurate answer and strike through the other(s). *(8 points: 1 point for each correct response)*

Answer:

Questions	Responses
Estimate missing ash value (1 point)	• ~~Sum up all minerals~~ • Copy the ash value of the same food from the preferred FCDB • ~~Copy from the preferred FCDB the ash value of a similar food~~
If the compilation is done in an Excel spreadsheet, is it possible to document nutrient values at the value level? (1 point)	• Yes, documentation is possible at food level (default for all data) and at value level (e.g. enter row below each line with nutrient values and document the value in cell below if default is not applicable and through the other worksheets) • ~~No, documentation is only possible at food level~~ • ~~No, documentation is not possible~~
'Orange, raw' has a missing AOAC (Prosky) dietary fibre value in the Kenyan FCDB. Which food should be chosen to copy dietary fibre value from? (1 point)	• 'Orange, raw' from USDA (Prosky fibre) • ~~'Orange, raw' from British table (Englyst fibre)~~ • ~~'Orange, raw' from FAO FCDB for Africa (crude fibre)~~
Boiled pasta is missing in the FCDB, while values for raw pasta exist. How can values for boiled pasta best be obtained? (1 point)	• ~~Copy from British table as they have the same food~~ • Calculate them in own FCDB by applying the mixed method • ~~Calculate them in own FCDB by applying the raw ingredient method~~
Kellogg's Cornflakes is not yet in the national FCDB in Thailand. It is a highly-consumed, non-fortified product and can be imported from the USA or Europe. How can values be obtained? (1 point)	• Ask the manufacturer to provide data • ~~Copy from USDA from same food~~ • ~~Copy from UK FCDB~~
Raw dark orange-flesh sweet potato has missing carotene values in Australia. Select the most appropriate way to obtain carotene values. (1 point)	• ~~Copy NV from raw, orange-flesh sweet potato (USDA)~~ • ~~Copy NV from raw, orange-flesh sweet potato (UK)~~ • ~~Copy NV from raw sweet potato (New Zealand)~~ • ~~Average NV of all of them~~ • Select the highest carotene values between USDA and UK
A compiler is looking for vitamin A values (in RAE) and finds data with different vitamin A definitions. Which data should be selected? (1 point)	• ~~Take only data in RAE~~ • Take data in RAE and data in RE if there are little or no carotenes • ~~Take all vitamin A data~~
Dried lean beef is missing in the FCDB while NV for raw lean beef exists. How can values be obtained? (1 point)	• Measure/estimate water content of dried lean meat and calculate other nutrient values • ~~Copy NV from other FCDB of dried fatty beef and change fat value~~ • ~~Copy NV from other FCDB of dried lean mutton~~

FCDB = food composition database; NV = nutrient values

For your information:
The sum of all minerals would give in most cases a too-high ash value. When not all mineral values are available, the calculated ash value would be too low.

AOAC dietary fibre values are significantly higher than Englyst or crude fibre values (see module 4.d for more information) and should therefore not be taken.

It is more appropriate to calculate the nutrient values than to copy them. British pasta is very softly cooked and might not correspond to the preparation of boiled pasta in one's own country. In addition, the pasta might be different. The raw ingredient method is not applicable to cooked food.

It is better to obtain the nutrient values from the manufacturer of the commercial product as the composition may change depending on the country (e.g. fortification, ingredients) even though it is imported from another country. Only when no data are obtained from the manufacturer, the nutrient values should be copied from another food composition database or table.

Orange-flesh sweet potatoes have a high carotene content. The one from New Zealand is not suitable, even though geographically the nearest, because it is not orange and therefore, the carotene content would be too low. As the Australian one is dark orange flesh, it is advisable to choose the highest carotene values between the UK and USDA values.

It might be necessary to copy vitamin A values expressed in RE even though RAE is the required definition. If foods contain no or small amounts of carotenes, RE and RAE are similar. In such a case, RE can be copied which minimizes the amount of missing data.

It is preferable to calculate dried, lean beef by measuring water change than to copy data from a similar food and adapt nutrients to difference in fat, water or protein content. The measurement of water content or change is relatively cheap.

GENERAL FEEDBACK USING SELF-SCORING

81 – 113.5 points: You have fully understood and integrated the principles of 'Recipe and other calculations'. Congratulations. You are well prepared to proceed to the next module and to apply the new knowledge.

51 – 80 points: You have understood and integrated most of the principles of 'Recipe and other calculations'. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so in order to effectively apply the new knowledge.

26 – 50 points: You have understood and integrated a fair part of the principles of 'Recipe and other calculations'. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

0 – 25 points: It seems you have significant gaps in your understanding of the principles of 'Recipe and other calculations'. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so in order to effectively apply the new knowledge.

Module 9

FOOD COMPOSITION DATABASE MANAGEMENT SYSTEMS AND DATA INTERCHANGE

LEARNING OBJECTIVES

By the end of this module the student will be able to:

- understand the principles of database management and different options for managing food composition data;
- discuss database management issues with developers and computer specialists;
- understand the principles of data interchange and its relation to documentation and database management;
- appreciate the complexity of database management for food composition because of the great amount of metadata.

REQUIRED READING

- **Charrondière, U.R**. Food composition database management systems and interchange. PowerPoint Presentation. Available at: ftp://ftp.fao.org/es/esn/infoods/Recipecalculation.pdf

and if possible:

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use*. FAO, Rome. Chapter 1 (pp. 10-12 of the book, not of the PDF file). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf
- **Klensin, J.C.** 1992. *INFOODS food composition data interchange handbook*. United Nations University, Tokyo. Part I (Introduction to the interchange system, Technical overview, and Introduction to reference material) pp. 5-25 and Glossary pp. 143-148; these page numbers are of the PDF file. Available at: http://www.unu.edu/unupress/unupbooks/80774e/80774E00.htm or as PDF file at ftp://ftp.fao.org/es/esn/infoods/Klensin%201992INFOODSDataInterchangeHandbook.pdf
- **FAO.** 2004. *Report of the Technical workshop on Standards for food composition data interchange*, FAO, Rome. pp. 1-4. Available at: ftp://ftp.fao.org/es/esn/infoods/interchange.pdf
- **Møller, A. & Christensen, T. in collaboration with Unwin, I., Roe, M., Pakkala, H. & Nørby, E.** 2008. *EuroFIR Web Services - Food Data Transport Package, Version 1.3*. Danish Food Information. EuroFIR D1.8.20. pp. 5-6, 14-24. Available at: http://www.eurofir.org/eurofir/Downloads/XML%20Food%20Transport%20Package/EuroFIR_Food_Data_Transport_Package_1_3.pdf
- **EuroFIR,** 2006. *EuroFIR IA 1.4. Report on specifications and plan for development of the EuroFIR databank system*. 18 September 2006. Prepared by **Møller *et al.*** pp. 5-11, 19-21, 26, 36-37 (other pages are suggested for further reading). Available at: http://www.eurofir.org/eurofir/Downloads/Databank%20Specifications/EuroFIR%20Databank%20System%20Specifications%202006-09-19%20AM.doc

EXERCISE MATERIAL

- Compilation Tool version 1.2.1. Available at: http://www.fao.org/infoods/software_en.stm
- **FAO.** 2004. *Report of the Technical Workshop on Standards for food composition data interchange*. FAO, Rome.: schema (at ftp://ftp.fao.org/es/esn/infoods/schema.pdf) and 'Set of files, elements and definitions' at ftp://ftp.fao.org/es/esn/infoods/definitions.pdf

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts +

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1–4 hours
- Answering the questions: 1–2 hours
- Completing the exercises: 1–2 hours

SUGGESTED ADDITIONAL READING

Food composition database management system and interchange

- **Schlotke, F., Becker, W., Ireland, J., Møller, A., Ovaskainen, M.L., Monspart, J. & Unwin, I.** 2000. Eurofoods recommendations for food composition database management and data interchange. Report No. EUR 19538. *Office for Official Publications of the European Communities, Luxembourg*. Available at: ftp://ftp.fao.org/ag/agn/infoods/EurofoodsRecommendations.pdf
- **EuroFIR** technical website on Systems Development Task Group (WP1.8 TG3) http://www.eurofir.org/eurofir/SystemsDevelopment.asp
- **Møller, A. & Christensen, T. in collaboration with Unwin, I. & Roe, M.** 2008. *EuroFIR XML Food Data Transport Package Specifications - Draft Report 2006-08-20*. Available at: http://www.eurofir.org/eurofir/Downloads/Food%20TransportPackageXMLTemplate%20and%20Specifications%202006-08-20_MAR_IU_AM.doc
- **Møller, A., Unwin, M., Ireland, J., Roe, M., Becker, W. & Colombani, P.** 2008. *The EuroFIR Thesauri 2008. Danish Food Information. EuroFIR D1.8.22.* Available at: http://www.eurofir.org/eurofir/Downloads/Thesauri/EuroFIR%20Thesauri%202008.pdf
- **Burlingame, B., Cook, F., Duxfield, G. & Milligan, G.** 1995. Food Data: Numbers, Words and Images. In: Quality and Accessibility of Food-Related Data - Proceedings of the First International Food Data Base Conference. *AOAC International - The Scientific Association Dedicated to Analytical Excellence,* Second edition. Greenfield (ed)

Database management systems (in general)

- http://dbis.ucdavis.edu/courses/sqltutorial/tutorial.pdf
- **MySQL**
  - http://oreilly.com/catalog/9780596514013/
  - http://oreilly.com/catalog/9780596514334/
  - http://oreilly.com/mysql/
- **Entity-relationship (ER) models and diagrams:**
  - http://www.csc.lsu.edu/~chen/pdf/erd-5-pages.pdf
  - http://citeseer.ist.psu.edu/old/519283.html
  - http://www.vocw.edu.vn/content/m10538/latest/
  - http://channel9.msdn.com/shows/Going+Deep/Dr-Peter-Chen-Entity-Relationship-Model-Past-Present-and-Future/
- **Relational databases**
  - **Klensin, J. & Romberg, R.** Statistical Data Management Requirements and the SQL Standards: An Evolving Comparison', in Rafanelli, M., Klensin, J. & Svensson, P. 1989. Statistical and Scientific Database Management: Fourth International Working Conference on Statistical and Scientific Database Management, Rome, Italy, June 1988, Proceedings. *Springer-Verlag, Berlin/Heidelberg* (Lecture Notes in Computer Science #339).
  - http://www.amazon.com/Database-Depth-Relational-Theory-Practitioners/dp/0596100124/ref=sr_1_4?ie=UTF8&s=books&qid=1244151342&sr=1-4
  - http://www.amazon.com/Database-Systems-Complete-Book-2nd/dp/0131873253/ref=sr_1_1?ie=UTF8&s=books&qid=1244153221&sr=1-1
- **Scientific and Statistical Database Management**: see Greenfield & Southgate, 2003, proceedings of annual conferences. Available at: http://www.ssdbm.org/
- **XML (Extensible Markup Language)**
  - http://www.w3.org/XML/
  - http://www.w3schools.com/xml/xml_syntax.asp
  - http://www.xmlgrrl.com/publications/DSDTD/go01.html
  - http://www.xml.com/
  - http://xml.sys-con.com/node/40070
  - http://oreilly.com/catalog/9780596007645/
  - http://www.xml.com/pub/a/axml/axmlintro.html

Answers to the questions

IX.Q1 Match the terms to the corresponding objectives. *(2 points: ½ point for each correct response)*

Terms:
1. Documentation
2. Food composition database management system
3. Data interchange

Answer (see also Klensin, 1992, pp. 5-7):

Term	Objectives
2	To provide the technical means for importing and exporting food composition data together with their metadata from and into one's own database
1	To explain data by providing additional information (metadata) to be able to both evaluate them and trace their values back to the origins
3	To communicate food composition data to others in an precise and understandable manner
2	To enable compilers to collect, document, compile and manage food composition data using standard procedures, codes, symbols, thesauri, etc.

IX.Q2 As documentation is crucial for food composition, every database management system should be able to handle data documentation. Indicate the data/metadata that are mandatory to understand food composition values and those that provide useful information. Indicate 1 for mandatory documentation, and 2 for documentation that provides additional useful information on the data. *(7 points: ½ point for each correct response)*

Answer:

	Food composition documentation – mandatory (1) or optional (2)
1	Analytical method if the value is method-dependent, i.e. different analytical methods generate significantly different values (empirical methods)
2	Analytical method if the value is method-independent, i.e. all analytical methods provide similar results (rational method)
2	Authority and sender of data
2	Bibliographic references or source of data
2	Recipe calculation, including method, yield and nutrient retention factors, as well as the recipe with its ingredients
2	Component group
1	Component name and definition, e.g. INFOODS tagnames[31]
1	Food name and description
2	Food group
1	Denominator (also called matrix unit, basis, base quantity, base unit)
2	Portion size
2	Sampling size, plan and handling
2	Contributing values for mean or calculated values
1	Unit

[31] See module 4.b

For your information:
For any given value, the exact food, component, unit and denominator must be known, otherwise the value is not complete and becomes useless. In addition, for method-dependent values, it is necessary to assess the analytical method used to ensure that values can be combined and compared. This documentation should also be regarded as the minimum requirement for database quality, data quality assessment and data interchange. However, for method-independent values (determined by a rational method), documentation of the analytical method is not obligatory because all methods generate similar values, in theory.

Some might also consider authority and sender as essential as it is important to know who send these data and who is responsible for the data. This information is however not mandatory to understand the data.

IX.Q3 Match the data support to the corresponding advantages/disadvantages for data documentation. Multiple answers are possible. *(3 points: ½ point for each correct response)*

Data support:
1. Electronic files, e.g. Excel files or other spreadsheets
2. Compilers' memory
3. Relational databases such MySQL, SQL, MS Access, ORACLE (as stand-alone software in one computer, or network of different workstations, or web-based hyperlinks)
4. Paper documents
5. XML data files or equivalents

Answer:

Term	Advantages/disadvantages for data documentation
3	It is least prone to errors and allows for data entry and management of multidimensional documentation, even of large data sets.
4	It allows for very detailed data documentation but is rarely put into electronic format (e.g. because of lack of time); in most cases, it is archived in a storeroom and may ends up in a paper bin.
3, 5	It allows data to be documented in electronic format and be exported for data interchange, but requires software proficiency and technical skills.
1	It allows data to be documented in electronic format, but multidimensional documentation is difficult. It calls for some technical skill and meticulous attention to managing the data.
3	It allows data to be documented in electronic format, but is very expensive and takes a long time to develop, customize and optimize.
2	It is not written anywhere, which makes it difficult to retrieve or trace the documentation and it is usually lost when people relocate or retire.

For your information:
XML data files can be generated through 'Office 2007' Windows 2008 (Vista) from Microsoft Word documents or Excel spreadsheets. This means that if data are stored in a well-conceived and well-structured format in Microsoft Word or Excel, the corresponding XML output files can easily be interchanged.

Most of the databases developed 20 years ago started with data documentation on paper (if it was done at all: some did not document data on any physical medium and the information was just retained in the minds of the compilers). Nowadays, electronic files or relational databases are most commonly used.

All data collected as paper records, e.g. on food samples, should have a corresponding field in the food composition database management system (FCDBMS). For example, the information on food samples (see Greenfield and Southgate, 2003, pp. 75-78 of the book) is useful to collect if it can be incorporated into the FCDBMS. If the data remains solely on paper, there is less likelihood of them being used.

IX.Q4 Match the forms of relational databases to the corresponding advantages and disadvantages. In one case, multiple responses are possible. *(2.5 points: ½ point for each correct response)*

Relational databases:
1. Stand-alone software in one computer
2. Network of different workstations
3. Web-based

Answer:

	Advantages/disadvantages of different forms of relational databases
3	Several persons with Internet and user access can work on the database simultaneously
2	Several persons linked to the same server can work on the database simultaneously
3	Link to the database is independent of location
1	Only one person can work on the database at a given time
2, 3	An efficient security system is needed to prevent viruses, unwanted access, etc.

IX.Q5 Determine the order of quality of database management system supports, from highest (1) to lowest (4). *(2 points: ½ point for each correct response)*

Answer:

Rank	Quality of database management system supports
2	Electronic files, such as Excel
4	Compilers' memory
1	Relational databases such MySQL, SQL, Access, ORACLE
3	Paper documents

IX.Q6 List three files that are part of a food composition database management system (FCDBMS). *(3 points: 1 point for each correct response)*

Note: It may be helpful to consult the Report (FAO, 2004) of the Technical Workshop on Standards for Food Composition Data Interchange, Rome, 19-22 January 2004: schema (at ftp://ftp.fao.org/es/esn/infoods/schema.pdf) and 'Set of files, elements and definitions' at ftp://ftp.fao.org/es/esn/infoods/definitions.pdf

Answer (see FAO, 2004):

Your answer should contain any three of the following:
- Component file (name and definition)
- Component value file
- Component group file
- Contributing value file
- Food item file
- Food name file
- Food description (e.g. national, INFOODS, LanguaL)
- Food group file
- Portion size
- Method file (analytical method and method description)
- Conversion factor file
- Sample file (sampling size, plan and handling)

- Unit
- Denominator (base unit file)
- Bibliographic reference file
- Component identifier thesaurus (e.g. INFOODS tagnames or EuroFIR component identifiers)
- Method headline file (codes for different analytical methods)
- Derivation type file
- Source type file

IX.Q7 Interchange of food composition data can be done in an informal manner or in a given format. Select True or False. *(4 points: ½ point for each correct response)*

Answer (see also Klensin, 1992, pp. 5-13; Moeller *et al.*, 2008, p. 5):

Correct statements about interchange	True	False
Interchange of food composition data permits data holders to share their data with other users.	x	
Data interchange normally occurs without the consent of either the sender or the receiver.		x
Data interchange requires that all types of data be packaged into a single file.		x
A prerequisite for interchange of food composition data is the unambiguous identification of food components. Therefore, INFOODS published the food component identifiers (also called tagnames) and EuroFIR the component thesaurus.	x	
Informal data interchange includes sending a simple food list of a food composition database without any compositional data because food names and descriptions are part of food composition data.	x	
The INFOODS proposition on interchange of food composition data was not widely implemented, until recently, because SGML[32] (and its profile XML[33]) was not fully understood by most compilers and computer specialist working on food composition and because of the lack of appropriate software tools. In addition, there were calls for a more formal and detailed list of elements to be included in data interchange.	x	
The EuroFIR proposal on interchange of food composition data is based on XML and is implemented among their partners.	x	
Interchange is facilitated by copyright restrictions.		x

For your information:
Food composition data can be interchanged as a single file, which ensures the integrity of the data set. However, data have been successfully interchanged as a set of related files corresponding to the different tables in a relational database (e.g. files for foods, components or compositional values). The original INFOODS interchange format was based on the SGML, which, at the time, was not well supported with user-friendly software tools, e.g. to interface with relational database management systems. Since then, XML, a profile of SGML, has been widely adopted and is well-supported by tools. Its use is essential for the Internet and data interchanges among computers, e.g. by so-called Web services. However, the development of XML applications still calls for significant resources and thus, at least in the short term, data are also interchanged using spreadsheet files or a set of related text files. Examples of such files are found at 'Data Interchange Files, elements and definitions - Proposed files, elements and definitions for the interchange of compositional data in food' (ftp://ftp.fao.org/es/esn/infoods/definitions.pdf). The XML Interchange format of EuroFIR is published by Moeller et al,. (2008), available at:
http://www.eurofir.org/eurofir/Downloads/XML%20Food%20Transport%20Package/EuroFIR_Food_Data_Transport_Package_1_3.pdf

32 Standard Generalised Markup Language, the language for structuring text upon which the Interchange Format was designed. It is specified in International Standard ISO 8879.
33 Extensible Markup Language.

IX.Q8 XML is often used for data interchange. In order to be able to read an XML file, some basic definitions should be understood. Therefore, in the table below, write the correct term next to the corresponding section of the interchange file in XML. *(3 points: ½ point for each correct response)*

Note: Explanations with regard to XML may be found at http://www.w3.org/XML/ and definitions of terms at http://www.w3schools.com/xml/xml_syntax.asp and http://www.xmlgrrl.com/publications/DSDTD/go01.html

Terms and definitions:

- **Element** is defined by ISO 8879 as "A component of the hierarchical structure defined by a document type definition; it is identified in a document instance by descriptive markup, usually a start-tag and end-tag."
- **Start tag** is defined by ISO 8879: **"**Descriptive markup that identifies the start of an element and specifies its generic identifier and attributes."
- **End tag** is defined by ISO 8879: **"**Descriptive markup that identifies the end of an element." Start and end tags must have exactly the same name.
- **Content** is defined as the data or information provided between start and end tag. It can be a text content or an element content – the latter is also called nested or child element.
- **Attribute** is defined by ISO 8879 as **"**A characteristic quality, other than type or content". An attribute is the information associated with an element. For example, if you think of an element as a noun, the attribute is an adjective. Attribute information for an element is stored in its start tag. An attribute consists of an attribute name and an attribute value. The attribute values are enclosed in quotes.
- **Nested element** is defined as an element directly contained by another element; the first is said to be a child of the second. It is also called child element.

Extraction of an interchange file in XML (from EuroFIR Food Data Transport Package[34])

<FoodNames>
<FoodName language="**en**" kind="**preferred**">**Butter, salted**</FoodName>
<FoodName language="**en**" kind="**synonym**">**BUTTER,WITH SALT**</FoodName>
</FoodNames>

Answer (see also Klensin, 1992, pp. 11-13 and 143-148):

Terms	Corresponding section of an interchange file in XML
Attribute	**language="en"**
End tag	**</FoodNames>**
Element	**FoodNames**
Content	**Butter, salted**
Nested element	**<FoodName language="en" kind="preferred">Butter, salted</FoodName>**
Start tag	**<FoodNames>**

[34] http://usda.foodcomp.info/Get_USDASR20_Food_Data_XML.asp?FoodId=01001,01002,01003

SAMPLE ANSWERS TO THE EXERCISES

IX.E1 Data documentation, which is important for data evaluation and interchange, is also possible with simple compilation tools. INFOODS and FAO have developed a simple compilation tool in Excel to allow compilers, in the absence of a sophisticated food composition database management system, to store, manage, document and publish food composition data. The Compilation Tool version 1.2.1 together with its user guide is freely available at http://www.fao.org/infoods/software_en.stm. Open the Compilation Tool version 1.2.1 (and the user guide) and look at the entered example data in the different worksheets. Indicate which documentation could be introduced into the different worksheets of this Excel spreadsheet. Select True or False. *(5.5 points: ½ point for each correct response)*

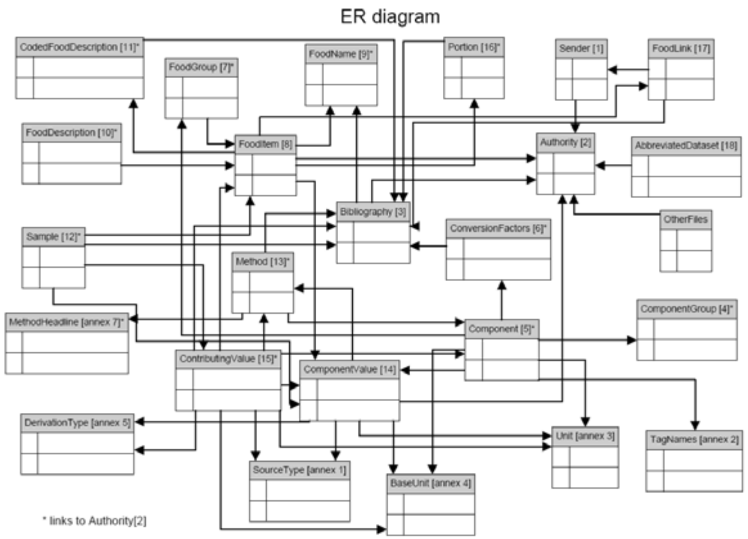
Answer:

True	False	Documentation that can be introduced into the Compilation Tool
x		Bibliographic documentation of sources of data and other references used
	x	Portion size
x		Documentation of analytical methods
x		Yield and nutrient retention factors with their sources, the recipe calculation method and the nutrient values of calculated foods and recipes
x		The main source of nutrient values at food level
x		The specific source of nutrient values at value level to supplement the default documentation at food level
x		Meaning of confidence and quality codes
x		Value documentation, e.g. value type, SE, SD, mean, date of analysis
	x	Faceted food description, e.g. LanguaL
x		Information on food samples
x		Ingredients and their quantities, with a short description of the preparation method

IX.E2 Many compilers have developed their own relational food composition database management system (FCDBMS) specific to their needs. Unfortunately, despite many attempts, no universal FCDBMS exists as yet. This would have been helpful for compiling, managing and interchanging food composition data in a harmonized manner. The 'Set of files, elements and definitions' and the 'data schema structure' (see ER[35] diagram below from FAO, 2004) could be used as guidance when developing one's own FCDBMS. Another example is the EuroFIR Food Data Transport Package (Møller and Christensen, 2008).

Note: The objective of this exercise is to appreciate the complexity of a FCDBMS due to multiple links among most files and the high amount of metadata. The intention of this exercise is not to fully understand ER models or to know how to construct them.

[35] Entity-relationship diagram



(a) List all the file names related/connected to the indicated file names. Multiple answers are possible. *(17.25 points: ¼ point for each correct response. Each of the multiple answers counts separately.)*

Answer (see FAO, 2004):

File name	Connected with following files
Authority [2]	FoodItem, CodedFoodDescription, FoodGroup, FoodDescription, FoodName, Portion, Sample, Bibliography, ComponentValue, Component, ComponentGroup, ConversionFactors ContributingValue, MethodHeadline, Method, OtherFiles, AbbreviatedDataset, Sender
Component Value [14]	Authority, FoodItem, ContributingValue, SourceType, Component, Method, Unit, BaseUnit, DerivationType
Component [5]	Authority, ComponentGroup, ConversionFactors, TagNames, ComponentValue, Method, Unit, BaseUnit, FoodGroup
Method [13]	Authority, Bibliography, MethodHeadline, ContributingValue, ComponentValue, FoodItem, Component
Sample [12]	Authority, Bibliography, ComponentValue, ContributingValue
FoodItem [8]	Authority, FoodItem, CodedFoodDescription, FoodGroup, FoodDescription, FoodName, Portion, Sample, ComponentValue, ContributingValue, FoodLink
FoodName [9]	Authority, Bibliography, FoodItem
Unit [annex3]	ComponentValue, Component, ContributingValue
BaseUnit[36] [annex4]	ComponentValue, Component, ContributingValue
SourceType [annex 1]	ComponentValue, ContributingValue

[36] Base Unit was also called 'base quantity' but as these are SI units it was decided to call it 'denominator' as a neutral mathematical term. EuroFIR uses the term 'matrix unit'. See Module 4c for more information.

(b) Open the file 'Data Interchange Files, elements and definitions' (FAO, 2004) at ftp://ftp.fao.org/es/esn/infoods/definitions.pdf. Search the files where the following elements are mentioned and write the corresponding file name (same as in the ER diagram above) for the elements indicated in the table below. Multiple answers are possible. *(17 points: 1 point for each correct response. Each of the multiple answers counts separately.)*

Answer (see FAO, 2004):

Element in file	File name
email	Sender, Authority
ISBN	Bibliography
componentid	Component, Method, ComponentValue, ContributingValue
unit	Component, ComponentValue, ContributingValue
sampplan	Sample
methcode	Method
sourcetype	ComponentValue, ContributingValue
portiondesc	Portion
g	Unit [annex 3]
W (per 100g edible portion)	BaseUnit [annex 4]

For your information:
The elements ending with '-id' (e.g. authorityid, componentid, fooditemid, methodid) are key elements with which the relational files are linked together. Therefore, they are always mandatory and are found in all files except the annexes. When key elements are repeated in several files, then these files are related/connected. You can verify these connections in the above ER diagram and the 'Data Interchange Files, elements and definitions' (FAO, 2004).

The annexes contain codes used in the different files. For example, units are found in annex 3 and must be indicated at different places, such as the default unit in the component file, and to define the component value and the contributing values.

FCDBMS are complex (i.e. many relationships between data files and many metadata) and are therefore difficult to develop, time-consuming and costly. In the past, many attempts to develop a global or even a national FCDBMS failed and/or did not include all functions desired by compilers.

There are several sets of database terminology, associated with different models (ER and classical relational technology), and they might use different words for the same meaning or the same words for different meanings. Therefore, when discussing database issues with a computer specialist, programmer or IT specialist, it might be helpful to agree on terminology right at the beginning to avoid confusion.

(c) Select the correct response, indicating whether the schema and the listed files take account of the difference between archival, reference and user database. *(1 point)*

Answer:

	The schema and listed files take account of the difference between archival, reference and user database
	Yes, because all keys and data fields are the same in archival, reference and user database.
x	No, because an additional layer is missing to indicate whether the data are stored and managed in the archival, reference and user database.

IX.E3 From the XML Food Data Transport Package, indicate the data content corresponding to the requested data in the table below. *(10 points: 1 point for each correct response)*

Example from the EuroFIR XML Food Data Transport Package[37]

```
<Food>
 <FoodDescription>
    <FoodIdentifiers>
      <FoodIdentifier system="origfdcd">
          <Identifier>01001</Identifier>
      </FoodIdentifier>
          <FoodIdentifier system="LanguaL">
          <Identifier>A0148</Identifier>
          <Identifier>B1201</Identifier>
          <Identifier>C0179</Identifier>
          <Identifier>E0119</Identifier>
          <Identifier>F0018</Identifier>
          <Identifier>G0003</Identifier>
          <Identifier>H0001</Identifier>
          <Identifier>J0135</Identifier>
          <Identifier>K0003</Identifier>
          <Identifier>M0001</Identifier>
          <Identifier>N0001</Identifier>
          <Identifier>P0024</Identifier>
          </FoodIdentifier>
    </FoodIdentifiers>
    <FoodClasses>
      <FoodClass system="origfdgp">0100</FoodClass>
    </FoodClasses>
    <FoodNames>
      <FoodName language="en" kind="preferred">Butter, salted</FoodName>
      <FoodName language="en" kind="synonym">BUTTER,WITH SALT</FoodName>
    </FoodNames>
  </FoodDescription>
  <Components>
    <Component>
      <ComponentIdentifiers>
          <ComponentIdentifier system="origcpcd">203</ComponentIdentifier>
          <ComponentIdentifier system="origcpnm">Protein</ComponentIdentifier>
          <ComponentIdentifier system="ecompid">PROT</ComponentIdentifier>
          <ComponentIdentifier system="INFOODS">PROCNT</ComponentIdentifier>
      </ComponentIdentifiers>
 <Values>
```

37 http://usda.foodcomp.info/Get_USDASR20_Food_Data_XML.asp?FoodId=01001,01002,01003


```
      <Value unit="g" matrixunit="W" methodtype="A" methodindicator="MI0123"
  methodparameter="6.38">
      <SelectedValue valuetype="MN" acquisitiontype="D">0.85</SelectedValue>
      <Mean>0.85</Mean>
      <StandardError>0.074</StandardError>
      <NumberOfAnalyticalPortions>16</NumberOfAnalyticalPortions>
      <MethodSpecification>
            <MethodId>1</MethodId>
            <OfficialMethod>Jones (1941)</OfficialMethod>
            <GeneralDescription>The values for protein were calculated from the level of total
  nitrogen (N) in the food, using the conversion factors recommended by Jones (1941). The general
  factor of 6.25 is used to calculate protein in items that do not have a specific
  factor.</GeneralDescription>
            <Remarks>N x Jones factor</Remarks>
      </MethodSpecification>
      </Value>
    </Values>
    </Component>
</Food>
```

Answer:

Data requested	Corresponding data content
Food code (identifier)	01001
Preferred food name	Butter, salted
Component name	Protein
INFOODS component identifier (tagname)	PROCNT (PROT since 2010)
EuroFIR component identifier (ecompid)	PROT
Unit	g
Denominator (matrix unit)	W
Value	0.85
Calculation method	N x Jones factor
n (number of independent analytical food samples)	16

For your information:
W = per 100g edible portion

IX.E4 A famous researcher generated compositional data for some foods and sent them to the national food composition compilers, thereby allowing them to incorporate the new data into the food composition database. List 10 additional information that the compilers should request from the researcher. From these 10 information, select the four mandatory ones that are essential to understand the data. *(14 points: 1 point for each correct response and 4 points for selecting the most important information correctly)*

	Vitamin C	Folate	Carbohydrates	Fibre	Energy	Iron	vitamin A
Spinach	28.1	194	3.63	2.2	97	2.71	9311
Fig	1	9	48.6	7.5	889	4.2	10
Lentil soup	1	4	12.7	3.8	413	1.2	36
Antelope	0				150	2.1	
Sweet potato	70		5.35		189	19.35	875

Answer:

Additional information requested on	Most important
Food description (leading to correct identification of the food, e.g. cooking method, preservation, origin, scientific name)	x
Unit and denominator (if in e.g. in g and per 100 g edible food)	x
Exact component definition (is needed for all components except for iron (e.g. if carbohydrates are with or without dietary fibre or if in monosaccharide equivalents)	x
Analytical method (is needed for vitamin C, folate, fibre and vitamin A because these values are method-dependent)	x
Source of data (if analysed, calculated or copied)	
Source/reference (if copied, from which source)	
If analysed: when, and key steps in method	
LOD/LOQ of the methods	
Quality assurance	
Number of samples, value range (minimum and maximum)	
Sampling protocol, region where food comes from	
Sampling handling	
Sampling storage	
Sample homogenization	
Data quality index	
Scientific name	
Recipe calculation method and ingredients	
Yield and nutrient retention factors used	
Meaning of missing values (are they not determined or not reported, or are they zero?)	
Proximate values (needed for energy calculation)	
Water value	
Significant figures	
Statistics (e.g. mean, SD)	
Contact details of sender	

For your information:
If you have listed the unit and denominator separately, you get half a point for each. Count only 1 point for all food descriptions (if you have listed them separately). This list may not be complete.

GENERAL FEEDBACK USING SELF-SCORING

76 – 91.25 points: You have understood and integrated the issues concerning database systems and interchange. Congratulations. You are well prepared to proceed to the next module and to apply the new knowledge.

51 – 75 points: You have understood and integrated most issues concerning database systems and interchange. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so before being able to apply the new knowledge.

26 – 50 points**:** You have understood and integrated a fair part of issues concerning database systems and interchange. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so before being able to apply the new knowledge.

0 – 25 points**:** It seems there are significant gaps in your understanding of issues concerning database systems and interchange. You should read the sections again and improve your knowledge of these topics before being able to apply the new knowledge.

Module 10

COMPILATION AND DOCUMENTATION

LEARNING OBJECTIVES

By the end of this module the student will:

- understand the principles of compiling, maintaining and updating food composition tables;
- be aware of the tasks to be undertaken when compiling archival, reference and user databases;
- be able to compile a simple food composition database, separated into archival, reference and user databases;
- know how to incorporate compositional data from different sources;
- understand the principles and importance of documentation;
- know how to document data at the value and food levels;
- be capable of managing food composition data (aggregate, document, complete).

REQUIRED READING

- **Charrondiere, U.R.** PowerPoint presentation on 'Basic principles for assembling, managing and updating food composition databases', available at: http://www.fao.org/infoods/presentations_en.stm

and if possible:

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use.* FAO. Rome. Chapters 1 (pp. 6-12 of the book, not of the PDF file), chapter 2 (pp. 24-29), chapter 9 (pp. 163-166) and chapter 10 (pp. 175-182). Available at: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf
- **Rand, W.M., Pennington, J.A.T., Murphy, S.P. & Klensin, J.C.** 1991. *Compiling Data for Food Composition Data Bases*. United Nations University, Tokyo. Section 1 (Data Base Considerations) pp. 6-18 and sections 3-5 (Calculating representative data; Data from other sources; Estimation of data on similar foods) pp. 24-43. Available as PFD file at ftp://ftp.fao.org/es/esn/infoods/Randeal1991CompFCDBases.pdf

EXERCISE MATERIAL

- FAO/INFOODS Compilation Tool version 1.2.1 (an Excel file available at http://www.fao.org/infoods/software_en.stm)
- USDA SR 22 abbreviated food composition database and nutrient definition file at the United States Department of Agriculture (USDA) website http://www.ars.usda.gov/services/docs.htm?docid=8964
- From the Danish food composition website http://www.foodcomp.dk/v7/fcdb_default.asp, the Excel file of the Danish food composition database version 7.01 and the documentation
- **FAO.** 2004. Report of the Technical Workshop on Standards for Food Composition Data Interchange, Rome. 19-22 January 2004. *FAO, Rome.* Available at: ftp://ftp.fao.org/es/esn/infoods/interchange.pdf

REFERENCE MATERIAL

- Excel help available at http://office.microsoft.com/en-us/excel/FX100646951033.aspx

RECOMMENDATION

Data compilation requires knowledge of component and food selection and nomenclature; basics of analytical methods and their quality; documentation and calculation. Therefore, it is highly recommended that students complete modules 1 and 3-8 before starting on the present module.

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts +

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1-3 hours
- Answering the questions: 1-3 hours
- Completing the exercises: 3-8 hours

Module 10 – Answers

Answers to the questions

X.Q1 Match the three compilation methods of food composition databases to the corresponding description and select the most frequently-used method. *(2 points: ½ point for each correct response)*

Compilation methods:
1. Direct method
2. Indirect method
3. Combined method

Answer (see Greenfield and Southgate, 2003, pp. 6-7):

Method	Mostly used	Description
2		All data are taken from the published or unpublished literature (e.g. scientific articles, laboratory reports), or are calculated or imputed.
1		All values are analysed, either specifically for the database or for other purposes.
3	x	Data for the compilation are derived from analyses and are complemented by data from, for example, the literature or calculations.

X.Q2 Match the types of food composition data to the corresponding definition and identify the type, which, in general, is of the highest quality. *(3.5 points: ½ point for each correct response)*

Type of food composition data:
1. Presumed values, e.g. zero values
2. Calculated values
3. (Original) analytical values
4. Imputed values
5. Borrowed values
6. Trace values
7. Missing values

Answer (see Greenfield and Southgate, 2003, pp. 7-9, 163-165):

Types definitions	Number	Highest quality
They are estimated from similar foods.	4	
The constituent is present in a food but cannot be quantified with the method used. In printed tables it is often recorded as T or tr.	6	
They are derived from recipe or other calculations (e.g. through arithmetic or weighted averaging of several data points).	2	
They are gathered from other sources (e.g. taken from other tables or the literature).	5	
They are based on laboratory measurements.	3	x
A value is not available and is therefore not recorded in the database. Often, these values are represented by -, N, ND, or are simply left blank.	7	
Their content is according to current knowledge of the contents of foods or regulations (e.g. no alcohol in cereals; no vitamin B_{12} or cholesterol in plant foods; no dietary fibre in animal foods; or iodine content in iodized salt according to regulated level of fortification).	1	

For your information:
As a general rule, original analytical values generated specifically for the national food composition database are of the highest quality and are the most appropriate type of data because they are measured in foods and sampled to represent the national food supply. Although analytical values are the best source of data, it is often necessary to partially complete a food composition database with borrowed, calculated, imputed or estimated data. These can be replaced with analytical data when they become available. In many cases, the first edition of a food composition table has a high percentage of imputed, borrowed and calculated data and this percentage often decreases with successive editions.

Trace is often expressed as "T" or "tr", and represents the only acceptable non-numeric entry in a data value field. "Trace" means that the constituent is present in a food but cannot be quantified with the method used, i.e. it is above the limit of detection (LOD) but below the limit of quantification (LOQ). With the evolution of methods, which often have a lower limit of quantification, it might become possible in the future to quantify constituents. Trace values are therefore method-dependent. "Trace" may be also used when the level is judged to be nutritionally insignificant. It is desirable to define these limits in the database documentation. Table 9.1 in Greenfield and Southgate (2003) (p. 165) contains suggestions with regard to trace values based on methods currently used. Trace values may be treated as zero, at LOD LOQ/2, depending on the nutrient and importance of the food. For highly-consumed foods, the contribution of a trace values can be significant in the nutrient intake estimation and the use of LOD/2 might be useful (e.g. the contribution of vitamin D made by milk, available in trace amounts, in countries where milk consumption is high).

X.Q3 What impact does a small budget have on the use of different data types when compiling a database? Select True or False. *(1.5 points: ½ point for each correct response)*

Answer (see Rand *et al.*, 1991, p. 8):

Impact of a small budget on the use of different data types	True	False
The lower the budget available, the higher the percentage of imputed, calculated and borrowed values and the lower the percentage of analytical data.	x	
In general, the higher the budget available, the higher the amount of analytical data.	x	
In general, the budget available does not have any influence on the amount of analytical data.		x

For your information:
Even if a higher budget is available, it is not always advisable to set up a laboratory because it requires large amounts of funding for instruments, staff, maintenance and running costs. In addition, it takes a long time before good-quality analytical data can be obtained. Therefore, when the time frame is short and there is no certainty of a sustainable budget it is preferable to outsource the analytical work instead of setting up a laboratory. See also module 1 the first exercise I.E1.

X.Q4 Imagine you are compiling a database from an extensive collection of old data stored as paper records and from printed food composition tables published many years ago. Indicate whether the following tasks are virtually impossible to complete or are simply a lot of work, especially considering that analytical data are rarely available. *(5 points: ½ point for each correct response)*

Answer (see Rand *et al.*, 1991, pp. 11-13, 33-43):

Compilation tasks	Almost impossible task	High work-load
Find appropriate data for all consumed foods and recipes and evaluate them.	x	
Find a full set of metadata for all foods and components in available resources so that values can be traced back to their origin and be subsequently evaluated.	x	
Find a full set of data and metadata for processed foods when only labelling information is available and manufacturers are not very cooperative.	x	
For all reported foods, identify the most similar food in an existing food composition table to borrow their nutrient values, i.e. judge similarities and differences among foods and their nutrient contents.	x	
Correctly identify the component definition in all sources.	x	
Identify a reliable recipe calculation system and related factors.		x
Calculate recipes.		x
Represent nutrient values in user tables and databases in accordance with the pre-defined maximal number of decimal places.		x
Judge the quality of analytical data in a standardized and comparable way.		x
Check data for accuracy and consistency before publishing.		x

For your information:
The following tasks simply involve a lot of work: identify a reliable recipe calculation system and related factors; calculate recipes; present nutrient values in user tables and databases in accordance with the number of decimal places decided; and check data for consistency and errors before publishing. In some cases, however, not all information is available to calculate a recipe (e.g. nutrient values of some ingredients) – in this case the recipe calculation becomes a challenge or an almost impossible task. As data quality assessment systems exist for analytical data (see module 11), the judgement of the quality is a high work-load. On the other hand, as no quality assessment systems exists for calculated or estimated values, judging data quality in a systematic manner is impossible until now.

Foods may seem similar but may have different nutrient contents because of variabilities among cultivars (see module 12), or different growing conditions, feeds, maturity, processing or fortification, etc. (see module 3). Care should therefore be taken when borrowing data.

X.Q5 Match the compilation steps to the corresponding tasks to compile a food composition database. Multiple choices are possible. *(6 points: ½ point for each correct response)*

Compilation steps:
1. Constructing the archival database
2. Managing data in the reference database
3. Constructing the user database
4. Carrying out preparatory work (before entering data into the database or before publishing the database)

Answer (see Greenfield and Southgate, 2003, pp. 10–12, 24-29):

Tasks to compile a food composition database	Step
- Set up a steering committee composed of stakeholders and users - Obtain training in food composition (e.g. distance learning and/or classroom courses) - Network with compilers, analysts and users from other countries and with international networks or organizations - Prepare a budget proposal, and approach potential donors - Obtain information on users' needs - Select a database management system	4
- Enter a food code for each food when incorporating the nutrient values into the database - Incorporate the newly-generated analytical data - Document sources of original data in one's own database	1 (,2 if new foods are directly entered into reference database)
Calculate nutrient values of recipes and document data source	2
- Collect and review existing information - Decide on component definitions and units - Select foods, nutrients and food groups - Collect recipes, including ingredients - Collect published and unpublished literature containing analytical and other compositional data	4
- Develop (or provide input into) sampling plans and analytical programmes - Supervise the analytical programme (in some cases) - Evaluate analytical reports	4
Enter the original data of the selected literature in electronic format	1
- Complete missing values and document data sources - Estimate and impute data - Scrutinize, standardize and aggregate data	2
- Prepare data to be published and disseminated - Incorporate introduction, index and other information for publishing	3
Maintain and update the data in the reference database	2
- Develop guidelines for disseminating data to users (e.g. fees to be paid by commercial users, research institutes, others) - Select the support for publishing the data (e.g. printed or via the Internet)	4
Standardize decimal places and significant figures for each nutrient in the database to be published	3
Create a strong institutional framework including obtaining an authorization (e.g. from the government) to be designated as the responsible organisation to develop and maintain the national food composition programme	4

For your information:
See also table 1.1 of Greenfield and Southgate (2003) on page 11.

The archival records should hold all data and metadata in the units in which they were originally published or recorded. When Excel spreadsheets are used, units should be standardized when entered into the database because it is both difficult and cumbersome to hold more than one unit (and denominator) per nutrient in a spreadsheet. All values should be documented with metadata (e.g. unit, factors, calculation, sampling plan, numbers of food samples analysed, the analytical methods used and any quality assurance procedures in place). Such records should avoid the need to refer back to the original data sources if queries arise.

Ideally, foods and nutrients for the user database should be selected in collaboration with users.

Training of compilers in food composition (in classrooms, by exchange programmes or through distance learning) is highly recommended, as is the use of internationally recommended standards, procedures and factors.

X.Q6 From the list below, select the least important task involved in successfully compiling and maintaining a food composition database. *(1 point)*

Answer (see Rand *et al.*, 1991, pp. 11-13):

Least important task for food composition database compilation and maintenance	Least important
Documenting all data	
Searching scientific literature for compositional data	
Creating a strong institutional framework including obtaining an authorization (e.g. from the government) to be designated as the responsible organisation to develop and maintain the national food composition programme	
Selecting food groups	x
- Creating a steering committee composed of stakeholders and users - Training in food composition (e.g. by distance learning and/or classroom courses) - Networking with compilers, analysts and users from other countries and with international networks or organizations - Preparing a budget proposal, and approaching potential donors - Collecting information on users' needs	

For your information:
In the past, many compilers have underestimated the importance of documentation and of a strong institutional framework, but both are essential in terms of ensuring a sustainable food composition programme.

X.Q7 A researcher needs to compile a food composition database for a certain research purpose, including calculation of composite dishes. Select the correct response describing the way the researcher might compile a high-quality database. *(1 point)*

Answer:

	Correct way of compiling a high-quality database
	Researchers should develop their own compilation procedures because the food composition database is for a specific purpose. This ensures that the database is adapted to local requirements and that the results are of high quality.
x	Researchers should consult international literature and authoritive websites to search for existing standards, so that the food composition database is developed in accordance with international recommendations, thus assuring good quality.
	Researchers should ensure that recipe calculations are in accordance with international standards and procedures because they represent the major part of the food composition database to be constructed. Other database issues can be dealt with in accordance with local requirements.

X.Q8 List five guidelines that may need to be elaborated before a database can be compiled and scrutinized. *(5 points: 1 point for each correct response)*

Answer (see Greenfield & Southgate, 2003, and PowerPoint presentation on 'Basic principles for assembling, managing and updating food composition databases', available at http://www.fao.org/infoods/presentations_en.stm):

Your answer should include any five of the following possible guidelines:
- Order of external sources for inclusion in a food composition database;

- Acceptance criteria of external data (minimal requirement and documentation);
- Documentation (mandatory, optional);
- Estimation of values of a similar food;
- Aggregation of foods and values;
- Calculation of nutrient values through recipes;
- Data checking for consistency and completeness;
- Presentation of statistical information;
- Presentation of component values (mode of expression, decimal places, significant digits, unit, denominator);
- Elaboration and use of data quality scores;
- Updating of existing data;
- Nomenclature of foods and components (name, description, definitions of terms used);
- Sampling protocols (if data are analysed);
- Analytical sample preparation and methods (if data were to be analysed).

For your information:
Ideally, these guidelines should be written before data are compiled and evaluated. They are very important for ensuring that procedures are consistently carried out among different persons and over time. However, the guidelines are often completed during compilation when unforeseen situations occur.

X.Q9 Select the criteria for selecting sources for compositional data for a food composition database. Select True or False. *(4.5 points: ½ point for each correct response)*

Answer:

Criteria to choose sources for compositional data	True	False
Documentation should be available to judge values and their quality.	x	
Data should be of high quality.	x	
Data should be readily available (e.g. in the public domain, on the Internet, in scientific literature or in published laboratory reports).	x	
Data should solely come from areas of geographical proximity.		x
Component definition and methods should always be the same as in one's own database.		x
All types of values (analytical, calculated, imputed, presumed, borrowed) are acceptable.	x	
Food description should be unambiguous.	x	
Data is acceptable only if it is in one's own language.		x
Data is acceptable if they are expressed in the same units.	x	x

For your information:
'Units' is a wrong criteria because in most cases they can be transformed into the desired unit. Language is often a criterion because not all data are available in the local language. Not all food composition data are readily available and sometimes have to be purchased.

X.Q10 Indicate whether the following issues are food-, component- or value-related in the management and use of food composition data. Multiple choices are possible. *(11 points: 1 point per line if all responses are correct)*

Answer:

Issues	Food-related	Component-related	Value-related
Coverage/completeness of data	x	x	x
The description system allows an unambiguous description	x	x	
Is representative of national food supply	x		
Definitions and/or thesauri exist	x	x	
Units and denominator			x
Reference exist to analytical method		x	
Naming, classification and coding	x	x	
Extent and treatment of missing data	x	x	x
Correspondence between components from other sources to component in one's own database		x	
Require documentation (e.g. source, analytical methods, definition, fortification, food sampling, statistical data)	x	x	x
Language	x	x	

For your information:
It is very important to establish the correspondence between the component definitions from other sources and the component definition in one's own database. It is recommended that INFOODS component identifiers (see module 4.b) be used or be matched to existing component names in one's own database and of other sources. In this way, the values are comparable and, in general, no additional method information or interpretation of comparability will be needed. If EuroFIR components are used, additional information on methods and data expression are needed, as well as recommendations on method comparability per component and food matrix. The EuroFIR system for components can be regarded as a description system with thesauri and descriptors.

X.Q11 Indicate the tasks to be undertaken before incorporating data from other sources, e.g. other food composition tables or databases. Select True or False. *(3.5 points: ½ point for each correct response)*

Answer (see Rand *et al.*, 1991, pp. 21-43):

Tasks be undertaken before borrowing data from other sources	True	False
Study the documentation of the data (e.g. introduction or documentation)	x	
Complete missing values		x
Establish correspondence between components from other sources and the component in one's own database (e.g. through attributing tagnames)	x	
Verify whether units and denominators are the same as in one's own database	x	
Check correspondence of analytical methods for components if determined through empirical methods	x	
Verify that foods are the same (or the most similar)	x	
Compare all values with the values of another source		x

For your information:
Food composition database management systems are normally programmed to convert units and denominators from other source into the ones in the database. The verification of units and denominators is however necessary.

X.Q12 Select the single most efficient way of copying values from an Excel file into a food composition database in Excel. *(1 point)*

Answer:

Most efficient way of copying values from an Excel file into an Excel database	
Copy each value separately, in the sequence in which they appear in the Excel database	
Arrange the format of the other Excel file into the same order of components as in the Excel database; then copy whole lines of nutrient values per food	x
Put all foods, from which values should be copied, into the order of foods as appearing in the Excel database; then copy the values nutrient-by-nutrient	

X.Q13 Some reference databases have specific data fields when components may have different values due to definition and/or analytical method. The values put into these data fields are the best estimates of the nutrient value for a given food and closest to the desired component definition or are calculated with a standard formula. The values of these specific data fields are published in the user database. In the Compilation Tool, the term 'standardized' nutrients was chosen for this kind of data field. Answer the following questions. *(8 points)*

Example: Among all dietary fibre definitions, the compiler decides that values for total dietary fibre (Prosky method) will be displayed in the user database. When other fibre definitions are found in the different data sources they are entered in the reference database into the corresponding data fields for the other fibre definitions. When preparing the data for the user database, the compiler selects for each food the most appropriate value to represent total dietary fibre (Prosky method) for the user database.

Note: It would be useful to consult the worksheet 'reference database' and 'component' of the Compilation Tool (available at http://www.fao.org/infoods/software_en.stm). 'Standardized' nutrients are shaded in yellow.

Answer:

Questions	Responses
Select the purposes of 'standardized' nutrients. ~~Strike through the incorrect one.~~ (1 point)	- To calculate nutrient values in a standardized manner - To select from existing data the most appropriate nutrient value for publication in the user database - To avoid incorporating errors from other sources when copying their calculated values ~~- To compare the different values for the nutrient depending on definition or analytical method~~
List three nutrients with 'standardized' nutrients (3 points)	Your answer should include any three of the following 'standardized' nutrients: - energy (specific energy conversion factors and contributing values are chosen. In the Compilation Tool, the energy values include energy from dietary fibre) - carbohydrates (one expression should be chosen. In the Compilation Tool, CHOAVLDF was chosen because it was supposed that its users do not have analytical data for carbohydrates) - dietary fibre (AOAC fibre is chosen in the Compilation Tool) - vitamins A, D, E, B_6, C - niacin/niacin equivalent - folate
Indicate the criteria for selecting the component to represent the standardized component. ~~Strike through the incorrect one(s).~~ (2 points)	- Availability of data - State of the art on component definition and analytical method ~~- language~~

	~~- unit~~
Where are the nutrient values of 'standardized' nutrients completed? Select the correct response. (1 point)	☐ Archival database ☒ Reference database ☐ User database
Select the correct reason why all contributing components for energy should have values. Select the correct response. (1 point)	☐ The standardized energy value would be too high if contributing values were missing ☒ The standardized energy value would be too low if contributing values were missing ☐ The standardized energy value would be too low or too high, depending on the missing component

For your information:
From the reference database, the compiler decides which value to select to represent the most appropriate value among several definitions of the same nutrient for a given food.

If any contributing value for energy was missing, its value would be too low because the energy from this proximate would not be included in the value.

X.Q14 It is important for compilers to know whether certain assignments are finalized before working further with the data. Normally, the incorporation, completion and checking of values are done per food. Once this process has been completed, values are checked for consistency and completeness per component and food group. Metadata are also checked for consistency and completeness. Match the tasks to the checks that need to be done before the tasks can start. Multiple answers are possible. *(2.5 points: ½ point for each correct response)*

Checks:
a. Check all values for consistency and completeness (could be done per food, food group, per component and for metadata);
b. Check that missing values were completed (ideally, there should be no missing data);
c. Verify that all steps in the recipe calculation are correct and that no errors occurred (e.g. production of zero values for missing values in all ingredients or too low values because of missing values for some ingredients) .

Answer:

Tasks	Finalization of assignment
Calculate nutrient values for recipes	a, b
Publish user database	a, b, c
Aggregate nutrient values of different foods	a, b
Transfer data from the recipe calculation to the reference database	c
Calculate 'standardized' nutrient values	a, b
Transfer the data from the different sources to the archival database	a

For your information:
It is most useful to indicate at the food level whether the following tasks have been completed:

- incorporation of values from source;
- missing data were completed as much as possible;
- checked for consistency and completeness.

It would also be useful to indicate that these tasks have been completed per food group, component or for the entire database. The indication at these different levels would help the compiler to understand which tasks still need to be completed before the database can be published. While the indication of checks and documentation on value level and for metadata is very cumbersome, it is possible to do in database management systems.

X.Q15 Indicate whether the analytical methods and/or definitions listed in the introduction or documentation are always applicable to all values for this nutrient. Select True or False. *(2.5 points: ½ point for each correct response)*

Answer:

Analytical methods and/or definitions, as indicated in the general data documentation, are applicable to all values in the database	True	False
By definition, if a method is indicated in the general documentation, it is applicable for all values for this nutrient. Therefore, all nutrient values are determined by means of the analytical method indicated.		x
All nutrient values should correspond to the definitions indicated in the general documentation if they are calculated within this database (e.g. energy).	x	
When a compiler is unable to find a nutrient value with the desired analytical method or definition, a nutrient value not exactly corresponding to the desired analytical method or definition may be incorporated to minimize missing values. Therefore, not all nutrient values correspond necessarily to the indicated analytical method and/or definition.	x	
Only documentation at the value level allows users to know the analytical method and/or definition for each value.	x	
Some food composition databases have not stored the formula or any contributing values and conversion factors for the calculated values. This prevents nutrient values being recalculated in the event component definitions change. In these databases, all nutrient values are calculated in accordance with the new definition indicated.		x

For your information:
In general, compilers seek data with the exact nutrient definition and analytical method as in their own databases. However, it may happen that no such data are available; in these cases a compromise should be found so as to minimize missing values leading to incorporating values from nutrient definitions that are not optimal. For example, in one's own database, dietary fibre should be determined with the AOAC (Prosky) method. If no such value can be found for a particular food, an Englyst dietary fibre value (NSP – non starch polysaccharide) may be taken. In some cases, compilers may even take a crude fibre value because this is the only value available for this food in all sources examined, and then mark it as being a crude fibre value. However, the incorporation of a crude fibre value should be avoided at all costs. Therefore, many compilers would rather have a missing value than a crude fibre value.

It is advisable to avoid copying calculated values from other sources (especially with regard to energy, but also vitamin equivalents). It is recommended that these values be always calculated in one's own database based on the contributing values and the definition chosen. The user of data from other sources cannot be assured that the value is really calculated according to the definition, except when all contributing values and their conversion factors are listed and a recalculation is possible.

The only way to indicate users the analytical method and/or definition of values is through documentation at the value level.

X.Q16 How is variability in nutrient values expressed in food composition tables and databases? Select True or False. *(2.5 points: ½ point for each correct response)*

Answer (see Rand *et al.*, 1991, pp. 28-29):

Expression of variability in nutrient values	True	False
Standard derivation (SD)	x	
Standard error (SE)	x	
Mean value		x
Median value		x
Nutrient ranges (minimum and maximum value)	x	

X.Q17 Select the correct responses as to whether the statistical variability of nutrient values should be published in user tables and databases. Select True or False. *(2 points: ½ point for each correct response)*

Answer:

Statistical variability of nutrient values to be published in user tables and databases	True	False
No, because no user is interested in such information.		x
No, because it is too complicated to publish such information.		x
Yes, it is useful to indicate the range of nutrient values for each food, especially if the number of analysed samples is listed.	x	
Yes, it is useful to indicate the range of nutrients which were calculated using mean values.		x

For your information:
The number of samples analysed should not be confused with the number of foods sampled or the number of replicates. For more information on this issue, see module 5 on sampling.

X.Q18 Many significant figures or decimal places give the impression of a very precise value. Select the one correct response concerning the number of decimal places (or significant figures) in user databases. *(1 point)*

Answer (see Greenfield and Southgate, 2003, pp. 165-166):

Number of decimal places (or significant figures) in user databases	
Put for every value the number of decimal places (or significant figures) as in the original data source or as calculated.	
Decide for each component the maximal number of decimal places (or significant figures) for the user databases. Round values accordingly, while not adding 0 to complete the number of decimal places.	x
Decide for each component the number of decimal places (or significant figures) for the user databases. Round values accordingly, while adding 0 to complete the number of decimal places.	
Decide only for some components the maximal number of decimal places (or significant figures) for the user databases. Round values accordingly, while not adding 0 to complete the number of decimal places.	

For your information:
User are given a false impression of precision when values have several significant figures or decimal places even though they are determined with an imprecise method (semi-quantitative method, method with high LOQ or if is calculated). Decimal places and significant figures are nutrient- and unit-dependent. Therefore, care should be taken to publish an adequate number of significant figures or decimal places for each component (e.g. energy values should never have decimal figures because they are a calculated approximation of the true energy content). See module 4.c for more information. In the user database it is recommended that the maximal number of decimal places per nutrient (and of significant figures) be fixed. However, zero values should not be added to existing values to "complete" the fixed number of maximal decimal places because, as said earlier, this would give a false precision to the value.

X.Q19 List five of the possible checks for data consistency. *(5 points: 1 point for each correct response)*

Answer (see Greenfield & Southgate, 2003, PowerPoint presentation on 'Basic principles for assembling, managing and updating food composition databases', Rand *et al.*, 1991, p. 33):

Your answer should include any five of the following possible checks for data consistency:

- Check sum of macronutrients is 100 g (acceptable range is 97-103 g):
  - Water + available carbohydrates + fat + fibre + protein + alcohol + ash = 100;
  - Water + total carbohydrates + fat + protein + alcohol + ash = 100;
- Water + dry matter ≈ 100;
- Absence of alcohol, starch, fibre, cholesterol, retinol in specific food categories, e.g. no fibre in animal products;
- The sum of soluble carbohydrates and starch is equal to available carbohydrates;
- Animal + plant protein = total protein;
- Animal + plant fat = total fat;
- Haem + non-haem iron = total iron;
- Sum of saturated, monounsaturated and polyunsaturated fatty acids is equal to total fatty acids but less than total fats (around < 95%);
- If total fats are equal to zero, fatty acids are also equal to zero, no fatty acid conversion factor exists and cholesterol is equal to zero;
- Oleic acid is less or equal to total monounsaturated fatty acids;
- Linoleic acid < sum of polyunsaturated fatty acids;
- Sum of individual fatty acids belonging to a fraction is equal to or below the value of the corresponding fraction;
- Check component identification, units and modes of expression;
- Ash value is higher than, or equal to, the sum of minerals (where K and P values should be multiplied by 3);
- Fortification levels;
- The vitamin content of processed foods should be lower than that of the corresponding raw food (except when fortified or dried);
- That all contributing components have a value, which are used to calculate another nutrient value, e.g. energy, CHOAVLDF, vitamin equivalents.

The list might not be exhaustive.

X.Q20 Match the format to the corresponding objective of presenting data in a user database. *(3 points: ½ point for each correct response)*

Format of user database:

1. One page per food in which nutrients are listed vertically with additional information on source, statistics, etc.
2. One row per food, and the nutrients are listed horizontally over one or several pages.
3. One row per food, and the nutrients are listed horizontally over one or several pages. In the row below, additional information is given for certain values such as range or sample size.
4. One row per food, and the nutrients are listed horizontally over one or several pages. After the food name, a short description on calculation or sampling is given.
5. One row per food, and the nutrients are listed horizontally over one or several pages. Additional data and information are provided in different (e.g. relational) files.
6. Nutrient values for selected foods and nutrients are listed in separate annexes.

Answer:

Objective for different formats of user databases:	
to present the few component values available for some foods.	6
to present as many foods and components as possible in a minimum number of pages, with additional information for selected values.	3
to present, per food, as many metadata as possible at one place.	1
to present as many foods and components as possible in a minimum number of pages while providing comprehensive information on metadata in separate files.	5
to present as many foods and components as possible in a minimum number of pages, with additional information on the food and source of values.	4
to present as many foods and components as possible in a minimum number of pages.	2

X.Q21 List five of the possible reasons for updating a food composition database. *(5 points: 1 point for each correct response)*

Answer (see Greenfield and Southgate, 2003, p. 29):

Your answer should include any five of the following:

- New varieties of plants;
- Changes in animal husbandry and butcher practices;
- New manufactured foods;
- Changes in consumption patterns;
- Changes in market shares of products and distribution;
- New ingredients for recipes;
- New recipe calculation system or new yield and nutrient retention factors;
- New genetically-modified foods (if they become available on the market and have different nutrient values);
- New components to be added to the database because of new evidence of health and disease associations or other public health interest (e.g. *trans* fatty acids, trace minerals, anti-oxidants, other plant constituents);
- New or changes in existing food legislation or regulations (e.g. AOAC fibre instead of NSP, or total nitrogen x 6.25, or fortification or labelling);
- Improved or new methods for analysing nutrients, e.g. dietary fibre or carotenes;
- New convention factors for equivalents, e.g. vitamin A equivalent;
- New analysed values (to replace copied nutrient values).

SAMPLE ANSWERS TO THE EXERCISES

X.E1 Open the Compilation Tool version 1.2.1 and look at the data and documentation in the different worksheets. Match the documentation listed in the table below to the worksheets where the documentation is introduced. *(4.5 points: ½ point for each correct response)*

Note: The Compilation Tool is available at http://www.fao.org/infoods/software_en.stm.

Worksheet:
1. Codes
2. Recipe calculation
3. Recipe + ingredients
4. Archival database
5. Reference database
6. Bibliography
7. Value documentation
8. Sampling
9. Methods

Answer:

Worksheet	Documentation introduced
6	Bibliographic documentation of data sources and other references can be entered into one field or it can be dispatched into the different fields, e.g. title, creatorpersonal, ISBN, etc.
9	Documentation of the analytical methods can be added here. In many cases, only the identity of the analytical method is known, especially when the value is derived from another food composition table or database. More information can be extracted and documented from scientific articles.
2	Documentation can be entered concerning yield and nutrient retention factors with their sources, the recipe calculation method and nutrient values of calculated foods and recipes.
5	The main source of nutrient values is entered at the food level (e.g. for aggregated and calculated foods). For single values, which are calculated, imputed or estimated,, the source (with food code) is entered at the value level to supplement the default documentation at the food level.
1	Documentation is entered on the meaning of codes and abbreviations used in the different worksheets.
7	Extensive documentation (e.g. value type, SE, SD, mean, date of analysis, etc.) of values is entered here for a component-food pair (keys are entered to identify food and component).
4	Documentation at food level can be entered on the source of nutrient values. A food code is also attributed to all new foods. This worksheet contains only original data. No values are calculated or estimated here.
8	Documentation can be entered on information on sampling and food samples.
3	Documentation can be entered on ingredients and their quantities and a short description of the recipe preparation. This information should be published in the user food composition table or database.

For your information:
Some database management systems automatically attach the source documentation entered at the food level to each value as a default.

X.E2 Open the worksheets 'reference database' and 'recipe calculation' of the Compilation Tool version 1.2.1 and match the following data to the documentation listed in table below. In the last column of the table, indicate whether the documentation is at the food or value level; put 1 for food level and 2 for value level. *(7 points: ½ point for each correct response)*

Data found in the worksheets 'reference database' or 'recipe calculation':
1. EDIBLE value of final record of 'Tomato, ripe, raw'
2. Final record of 'Tomato, ripe, raw' (except if indicated otherwise for specific values)
3. Omelette, with tomato
4. 'Flour, wheat, white' record 2
5. FASAT value for final record of 'Flour, wheat, white'
6. ALC value for final record of 'Flour, wheat, white'
7. Retention factors baked for EGG AND EGG PRODUCTS.

Answer:

Corresponding documentation found in the worksheets	Data	Documentation at the food or value level (put 1 for food and 2 for value level)
calc. with mixed method	3	1
UK 6th	7	1
average of record 1-3	2	1
DK7.01-0531	6	2
own sampling S1	4	1
US21-11529	1	2
calc DK7.01-0531*0.8	5	2

For your information:
'calc DK6-0531*0.8' corresponds to the adaptation of the value of 'saturated fatty acids, total' (FASAT) to the difference in fat content between the analysed mean fat value (1.3 g) of 'Flour, wheat, white' compared to the fat value (1.6 g) of 'Wheat flour' from' the Danish food composition database. '0.8' is the ratio between 1.3 g and 1.6 g.

X.E3 A compiler is starting to enter compositional data for some foods into the archival database. The table below represents an extract of the archival database. For the foods highlighted in yellow, enter a food code, decide if the nutrient values will be borrowed from the food composition database below or be calculated. Then enter the documentation of the selected data sources. *(18 points: 1 point if all entries for the food are correct)*

Note: Take the completed data for some foods in the table as examples.

Complete the missing data using the following instructions:
- Enter a food code into the column 'food codes/food groups': The first two numbers of the food code represent the food group, the third and forth numbers food subgroup, and last three numbers the code of the food within the group.
- Enter the type of food into the column 'type': put R for recipes (meaning that their nutrient values will be calculated using the mixed recipe calculation, which applies also for cooked foods when calculated) and F for food.
- If it is a food, match the food to the most similar one in the Danish food composition database version 7.01 and enter the corresponding documentation:
    - the corresponding abbreviated source into column 'source';
    - the food number into column 'food number in source';
    - the food name as in the source into column 'food name in source'.
- In the event that no food is similar enough, put '-' into the corresponding cells.

- If it is a recipe, enter 'calc. with mixed method' (calc. stands for calculated) into the column 'source'.
- Indicate whether the food match is exact (put 1) or similar (put 2) in the column 'match'. The food match is exact if the food names, including all descriptors, are exactly the same. A number of additional checks are needed for some foods before being able to decide if the match is exact or similar, e.g. for meat cuts, to ascertain whether the foods are really the same (in many countries the names of meat cut are the same even though they come from different part of the animal – see module 3 for more information) . A food match is similar if the food name or at least one food descriptor are different.

Foods from the Danish food composition database version 7.01 (to be indicated as DK7.01) with food codes and English names:

[0224] Rice, polished, raw
[1253] Margarine, 80% fat, for frying/baking, vegetable fat
[0340] Egg, chicken, whole, raw
[0659] Sweet potato, raw
[0821] Potato, old (February to June), raw
[0115] Potato, raw
[1275] Lentils, brown, dried, raw
[0147] Lentils, dried
[0682] Lentils, sprouted, raw
[0010] Aubergine (eggplant), raw
[0790] Tomato, Danish, ripe, raw
[0791] Tomato, imported, ripe, raw
[0306] Tomato, ripe, raw, origin unknown
[0523] Mangos, raw
[0451] Chocolate, fancy and filled
[0038] Chocolate, milk
[0154] Sugar, sucrose, white
[1112] Sugar, Demerara
[0927] Pork, loin, lean, raw
[5020] Pork, loin with rind, raw
[5016] Pork, chop, raw
[5004] Pork, tenderloin, trimmed, raw
[0284] Pork, meat, approx. 32% fat, raw
[0285] Pork, meat, approx. 10% fat, raw
[0098] Chicken, hen, flesh and skin, raw
[0097] Chicken, hen, flesh only
[1035] Chicken, flesh and skin, grilled
[0132] Chicken, flesh and skin, raw
[0131] Chicken, flesh only, raw
[0319] Tuna, in oil, canned
[0318] Tuna, in water, canned
[0321] Tuna, raw
[0170] Milk, partly skimmed, 1.5% fat
[1473] Milk, partly skimmed, 1.5% fat, organic
[0750] Milk, whole, cultured
[5030] Milk, 0.5% fat
[0366] Milk, dry, skimmed, powder
[0367] Milk, dry, whole, powder
[0304] Tea, leaves
[0305] Tea, ready-to-drink
[0327] Water, tap, drinking, average values
[0333] Yoghurt
[0866] Cream yoghurt, 9% fat, with fruit
[0334] Yoghurt, low fat, with fruit juice
[0153] Corn oil

[0482] Olive oil
[0271] Soya bean oil, refined
[0386] Bouillon, beef, concentrated, cube
[1055] Bouillon, beef, cube, prepared

Answer:

Food codes/ food group codes	Type R = recipe F = food	Foods/food groups	Match 1=exact 2=similar	Source	Food number in source	Food name in source
1.		Cereals and cereal products				
01001	F	Rice, white, raw	**1**	**DK7.01**	**0224**	**Rice, polished, raw**
01002	R	Rice, white, boiled		**calc. with mixed method**		
01003	R	Rice, white, fried with tomato		**calc. with mixed method**		
2.		Starchy roots and tubers and their products				
02001	R	Potato, without skin, boiled		calc. with mixed method		
3.		Legumes and their products				
03001	R	Lentils, boiled		calc. with mixed method		
4.		Vegetables and their products				
04001	R	Aubergine, fried		**calc. with mixed method**		
04002	F	Tomato, raw	**2**	**DK7.01**	**0790 (or 0791 or 0306 or average of all)**	**Tomato, Danish, ripe, raw (Tomato, imported, ripe, raw OR Tomato, ripe, raw, origin unknown OR best would be average)**
04003	R	Tomato, boiled		**calc. with mixed method**		
5.		Fruits and their products				
05001	F	Mango, raw	1	DK7.01	0523	Mangos, raw (but there are different varieties with different nutrient values!)
6.		Sugar, sweets and syrup				
06001	F	Chocolate bar	2	DK7.01	0451	Chocolate, fancy and filled
06002	F	Sugar, white	**1**	**DK7.01**	**0154**	**Sugar, sucrose, white**
7.		Meat and poultry and their products				
7.1		Red meat				
0701001	R	Pork, fatty, boiled		calc. with mixed method		
0701002	F	Pork, lean, raw	2	DK7.01	0285	Pork, meat, approx. 10% fat, raw

continued table

Food codes/ food group codes	Type R = recipe F = food	Foods/food groups	Match 1=exact 2=similar	Source	Food number in source	Food name in source
7.2		Poultry				
0702001	F	Chicken, whole, raw	1	DK7.01	0132	Chicken, flesh and skin, raw
0702002	F	Chicken, whole, grilled	1	DK7.01	1035	Chicken, flesh and skin, grilled
8.		Eggs and their products				
08001	F	Egg, chicken, raw	**1**	**DK7.01**	**0340**	**Egg, chicken, whole, raw**
08002	R	Omelette, with tomato		calc. with mixed method		
9.		Fish and their products				
09001	F	Tuna, canned in oil	1	DK7.01	0319	Tuna, in oil, canned
10.		Milk and its products				
10001	F	Milk, camel, liquid, standard		-		
10002	F	Milk, cow, liquid, low fat	1	DK7.01	0170	Milk, partly skimmed, 1.5% fat
10003	F	Milk, cow, liquid, semi-skimmed, fortified	2	DK7.01	0170	Milk, partly skimmed, 1.5% fat
10004	F	Milk, cow, powder, full fat	**1**	**DK7.01**	**0367**	**Milk, dry, whole, powder**
10005	F	Yoghourt, plain, 3.5% fat	2	DK7.01	0333	Yoghurt
11.		Fat and oils				
11001	F	Vegetable oil	2	DK7.01	0153 (or 0271)	Corn oil (or soya bean oil, refined)
11002	F	Margarine, 80% fat, vegetable fat	**1**	**DK7.01**	**1253**	**Margarine, 80% fat, for frying/baking, vegetable fat**
12.		Beverages				
12001	F	Tea, black, liquid	2	DK7.01	0305	Tea, ready-to-drink
12002	F	Tap water	1	DK7.01	0327	Water, tap, drinking, average values
13.		Miscellaneous				
13001	F	Stock cubes	2	DK7.01	0386	Bouillon, beef, concentrated, cube

For your information:
Food names should be created in such a way that similar foods are listed close to each other. This is very practical. If 'Milk, cow, semi-skimmed, fortified' were to be named 'Fortified milk, cow, semi-skimmed', it would be inconveniently listed before camel milk.

'Milk, cow, liquid, low fat' is ambiguous. It could be interpreted as semi-skimmed or skimmed milk. Both solutions are correct, even though semi-skimmed is more likely.

'Chicken, whole, grilled' could also be calculated. The documentation would be R for recipe and 'calc. with mixed method' as the source.

X.E4 Some foods shown in X.E3 cannot be calculated because the corresponding raw food is missing in the archival database. List the four foods that need to be added to the archival database from the Danish food composition database to calculate the nutrient values of the corresponding cooked food through recipe calculation. *(4 points: 1 point for each correct response)*

Answer:

Missing foods:
1. Potato, without skin, raw
2. Lentils, raw
3. Aubergine, raw
4. Pork, fatty, raw

X.E5 Take the food list in X.E3 and add or delete the following foods in the database and attribute new food codes. Insert them in alphabetical order within the food groups. Indicate where they should be added (e.g. before aubergine, boiled) and write the new food code. *(4 points: ½ point for each correct response)*

Answer:

Foods to be deleted or added	Indicate before which existing food the new food should be added	Food code added
Example: Add 'Beans, black, dried, raw'	**Before 'Lentils, boiled'**	**03002**
Delete 'Tea, black, liquid'	-	-
Add 'Juice, apple'	Before Tap water	12003
Add 'Bread, white'	Before Rice, white, raw	01004
Add 'Cheese, emmentaler'	Before Milk, camel, liquid, standard	10006

For your information:
A deleted food code should never be used again. The new food 'Juice, apple' should therefore be given new code 12003 (do not re-use 12001).

X.E6 Compile data for the food 'Milk, cow, powder, full fat' in the Compilation Tool version 1.2.1. Then complete the table below. *(13 points: ½ point for each correct response)*

Instructions:
- Copy the information (from X.E3) for item '10004' 'F' 'Milk, cow, powder, full fat' 'match 1' 'DK7.01' '367' 'Milk, dry, whole, powder' into the corresponding cells in line 20 of the worksheet 'archival database'.
- Copy the nutrient values from '0367 Milk, dry, whole, powder' from the Danish food composition database version 7.01 into the corresponding cells of the worksheet 'archival database'.
- Copy the completed line 20 of the 'archival database' into the worksheet 'reference database' into line 35; add a line below.
- Complete all 'Standardized nutrients', i.e. INFOODS tagnames in yellow followed by (standardized) by copying the formulas of other foods for ENERC(kJ) (standardized), CHOAVLDF(g) (standardized), VITA_RAE(mcg) (standardized), NIAEQ(mg) (standardized), and 'sum of proximates (own DB)' into the corresponding cell; or select the best estimate (e.g. dietary fibre).
- Enter the documentation in the row below the values if a value was created within the reference database by using:
    - 'calc.' if calculated (more details can be added, e.g. source+fdcode, or if adjusted to another nutrient, mention to which one);
    - 'est.' if estimated;
    - 'est. Z' if presumed zero;
    - 'from FAT' if the standardized value is the FAT value.

Congratulations

Now verify that you have made the compilation correctly by answering the following questions. Please copy the formulas, documentation (if the value is calculated or estimated) and values from the Compilation Tool into the corresponding answer.

Note: In order to calculate certain values, e.g. energy or 'available carbohydrates by difference', it is necessary for all contributing nutrients to have a value. The number of decimal places (DP) is also indicated for all nutrients in the worksheet 'component'.

Answer:

Nutrient with decimal places (DP) as indicated	Indicate the formula or the documentation at the value level as entered in the reference database	Value as in the reference database
FAT(g) (standardized) (2 DP)	from FAT	26.8
CHOAVLDF)(g) (standardized) (2 DP)	=100-V35-Y35-AB35-AT35-AZ35-BA35	37.20
FIBTG(g) (standardized) (1 DP)	est. Z	0
ASH(g) (2 DP)	-	5.9
ENERC(kJ) (standardized) (0 DP)	=Y35*17+AB35*37+AJ35*17+AZ35*29+AT35*8	2095
VITA_RAE(mcg) (standardized) (0 DP)	=BM35+(BN35/12)	238
VITD(mcg) (standardized) (2 DP)	from VITDEQ	1.20
VITE(mg) (standardized) (2 DP)	from VITE	0.68
NIAEQ(mg) (standardized) (3 DP)	=CP35+CQ35	6.82
VITB6C(mg) (standardized) (3 DP)	from VITB6-	0.302
FOL(mcg) (standardized) (0 DP)	from FOL	37
VITC(mg) (standardized) (2 DP)	from VITC	10.0
sum of proximates (own DB)	=V35+Y35+AB35+AG35+ AQ35+AW35+AX35	100

For your information:
The formula in 'sum of proximates (own DB)' checks the completeness of proximates in the reference database. It should be 100, but the acceptable range is 97-103. If it is higher or lower than this range, the compiler should check again all contributing values if any error has occurred (e.g. missing value in contributing component, error in copying or calculating values, or error in analytical values).

Before completing the missing value for 'CHOAVLDF (standardized)', the energy value was 1463 kJ

X.E7 Indicate the documentation to be inserted into the Compilation Tool version 1.2.1 when completing or aggregating food composition data. Also indicate the worksheet where the documentation is inserted. ***(8 points: 1 point for each correct response)***

Note: Do not compile the data; just complete the documentation in the table below.

Data to be used:

- The Compilation Tool is available at: http://www.fao.org/infoods/software_en.stm.
- Download the Excel file with the abbreviated database of USDA SR 22 from http://www.ars.usda.gov/Services/docs.htm?docid=17478. The documentation of the database is found in the same zip file. For the documentation in this exercise, use US22 to indicate the USDA SR 22.
- Download the Excel file with the abbreviated database of the Danish food composition database version 7.01 from http://www.foodcomp.dk/v7/fcdb_default.asp . Select 'download food data' and then click on the Excel file to download the abbreviated data file. For the documentation in this exercise, use DK7.01 for the Danish database.

Answer:

Task	Corresponding documentation	Indicate worksheet
Import nutrient values of 'Asparagus, white, raw' from the Danish database	**source**: DK7.01 **fdnumber of source**: 0816*	Archival database
For 'Asparagus, white, raw', complete the missing value of EDIBLE from USDA21 by selecting the most similar food	**Value documentation below value**: US21-11011	Reference database
Import original values of raw asparagus from the USDA database SR22	**source**: US21 **fdnumber of source**: 11011	Archival database
Enter a new record (final record for publication) in which you calculate the average of all nutrient values of raw asparagus from the Danish and USDA databases	**source**: average of record 1-2 (or: average of DK7.01 and US21)	Reference database

***** or [0008]

For your information:
The food most similar to 'Asparagus, white, raw' in the USDA SR 22 is 'Asparagus, raw'. It is impossible to know whether this is white or green asparagus or a mix of both. Green asparagus should have a lower edible part because it is usually thinner than the white one. Some values, such as for carotene, should be different but they are missing for both green and white raw asparagus in the Danish database. However, 'Asparagus, all types, raw' in the Danish database has a carotene equivalent value of 53 mcg/100g. 'Asparagus, raw' in USDA SR 22 could be green asparagus as the carotene values are relatively high (38 mcg VITA_RAE/100g food).

Other abbreviations would also be correct, such as DK7 for the Danish database or USDA21 for the USDA database.

X.E8 Calculate, from the following fibre values, the aggregated standardized FIBTG value. *(1 point)*

Note: To calculate the average of several values, only those nutrients that have the same definition as FIBTG should be included. See module 4.b for more information on the INFOODS component identifiers.

Answer:

Mango, raw	FIBTG(g) (standardized)	FIBTG(g) AOAC	FIBTS(g) Southgate	PSACNS (g) NSP	FIBC(g) crude	FIB- (g)
Record 1	1.9	**1.9**				
Record 2				**1.3**		
Record 3	2.3	**2.3**				
Record 4					**1.1**	
Record 5	2.0	**2.0**				
Average records 1-5	2.1					

For your information:
Some inexperienced users might average all values irrespectively of their definition which would be an error.

X.E9 In November 2008, a compiler received a laboratory report (no. 146) from LabTec on data for a traditional, unleavened bread made of white wheat flour, together with the sampling information. Located in city X, LabTec is accredited for analysis in the specific food matrix. In October 2008, ten breads (of 500 g each) had been sampled from local bakery stores in each of the major cities of the country's three main regions: In the North: cities A, B and C; in the South: cities D, E and X; and in the costal region: cities F, G and H). They were transported to the laboratory. Between 20 and 30 October 2008, the laboratory quartered and homogenized the samples, put into one composite sample per region, and analysed them in duplicates. The results are as follows:

Nutrient	Unit*	Value North	Value South plus capital	Value Costal region	Method used
Water	**g**	**32.7**	**33.9**	**31.3**	**Air oven drying at 100ºC**
Fat	**g**	**1.8**	**2.0**	**1.6**	**Acid hydrolysis and capillary GLC**
Protein	**g**	**7.5**	**7.1**	**7.4**	**Kjeldahl**
Ash	**g**	**1.9**	**2.1**	**2.2**	**Dry ashing**
Dietary fibre	**g**	**2.1**	**2.3**	**2.2**	**AOAC, Prosky**
Sodium	**mg**	**522**	**533**	**544**	**AAS with electrothermal furnace**
Vitamin E	**mg**	**0.32**	**0.29**	**0.36**	**HPLC**
Folate	**mcg**	**21**	**20**	**24**	**Microbiological assay**

* per 100g edible portion

Compile these data into the Compilation Tool version 1.2.1 by using the food codes 1002001-3 for the Northern, Southern and Costal region, respectively. Then aggregate the data under 'traditional, unleavened bread made of white wheat flour, average' and give the food code 1002004. Thereafter, complete the table below with the information that was inserted in the Compilation Tool. *(27 points)*

Note: It would be helpful to consult the Report of the Technical workshop on Standards for food composition data interchange (FAO, 2004) for an explanation of field names in the table below (available at ftp://ftp.fao.org/es/esn/infoods/interchange.pdf). For the calculation of mean, SD and median, use http://www.physics.csbsju.edu/stats/cstats_NROW_form.html

Answer:

Questions	Responses (State the information inserted in the Compilation Tool)
How many records for the traditional bread will be in the archival database? (1 point)	3
How many records for the traditional bread will be in the reference database? (1 point)	4
Using the abbreviation 'LabTec 146' as biblioid, indicate the information put into the field 'consolidated' and indicate the worksheet in parenthesis. (2 points)	Laboratory report no. 146, LabTec, November 2008 (bibliography)
Indicate the sample documentation under code S4 of the food sample from the North region to be inserted into the sample worksheet in the different fields. If no information is available, put '-'. (7.5 points: ½ point for each correct response)	**sampleid**: S4 **fooditemid or name in source**: 1002001 or Bread, traditional, unleavened, wheat flour, white, Northern region **sampplan**: ten breads collected from the North region from cities A, B and C in October 2008 and analysed between 20-30 October 2008 **sampdate**: 2008-10 **sampdesc**: traditional bread from local bakery stores **sampcoll**: North region from cities A, B and C **sampfdnr**: 30 **sampwght**: 15 kg (= 30 x 0.5 kg) **sampanr**:1 **sampanrep**: 2 **samphand**: quartered, homogenized **samparriv**: 2008-10 **sampstor**: - **sampreason**: for food composition programme **biblioid**: LabTec 146
Indicate the value documentation for water of the aggregated food sample from all regions to be inserted into the value documentation worksheet in the different fields. If no information is available put '-'. (13.5 points: ½ point for each correct response)	**biblioid:** LabTec 146 **fooditemid or name in source:**1002004 or Bread, traditional, unleavened, wheat flour, white, average **sampleid: S4, S5, S6** **componentid:** WATER **value:** 32.6 **unit:** g **baseunit:** W **n:** 3 **methodid of entire method:** M7 **QC (quality control):** RA **valtype (look in code worksheet):** MN **sourcetype:** AAG **derivtype:** AS **sd:** 1.30 **se (=sd/n):** 0.43 **min:** 31.3 **max:** 33.9 **mean:** 32.6 **median:** 32.7 **lowerror:** - **higherror:** - **qi:** - **analysedate:** 2008-10-20-30 **prepsampl in lab:** - **prepanadt:** 2008-10-20-30 **sepanadt:** 2008-10-20-30 **qtanadt:** 2008-10-20-30
List the two nutrients for which additional information is required before the data can be incorporated into the database. (2 points)	- Protein: nitrogen conversion factor is missing or nitrogen content is needed - Vitamin E: definition is missing. Is it α-tocopherol or α-tocopherol equivalent? And if it is latter, what is the definition?

X.E10 A compiler wishes to incorporate the carotene values of bananas (Fi's banana; Musa troglodytarum L.) found in the International Journal of Food Composition (IJFC), volume 1 (1), p. 1-20 of 2008. The author is K. L. Miller and the title is 'Carotene content of local banana varieties in Wonderland', a small island with 100,000 inhabitants. The method and material section provides the following description: The variety names were identified by key informants and market surveys, and then identified by their scientific name by the International Botanic Organization (IBO). In 2007, 20 bananas of each variety were collected from different markets. The dimensions and edible portion were measured, digital photos were taken, and the colour of the flesh was visually assessed (and classified in five categories) as well as by DSM detector (detecting 15 segments of yellow-to-orange). The peeled bananas were halved and one half was analysed raw and the other half boiled (10 minutes in a stainless steel pot) before analysing. The samples were deep-frozen at -80°C and shipped to an oversees laboratory for analysis. An HPLC method was used for the carotene analysis and the extraction, separation, identification and quantification are described by Smith *et al.* (2007). Samples were analysed in duplicates (variation under 8%) and an internal standard (β-apo-8'-carotenal) was used with a recovery of 97%. Riboflavin, ascorbic acid and α-tocopherol were also determined by HPLC. The results are as follows:

Banana variety and preparation	Number of analysed samples	Colour	Edible coefficient	β-carotene (mcg*)	α-carotene (mcg*)	β-crypto-xanthin (mcg*)	Water (g*)
Jammy, raw	3	3 (yellow)	0.63	432		ND	ND
Than, raw	4	4 (yellow)	0.67	806	360	ND	76
Than, boiled	4	4 (yellow)	0.67	960	355	ND	76
Khan, raw	3	8 (yellow-orange)	0.65	2588	1236	31	ND
Canot, raw	6	15 (orange)	0.72	8455	ND	ND	70

* per 100g edible portion
ND = not determined

Compile all these data in the Compilation Tool version 1.2.1 using the food codes 04001–04005. Then answer the questions in the table below. *(19.5 points)*

Answer:

Questions	Responses
How many records for the banana varieties will be in the archival database? (1 point)	5
Is there a need to change units for any of the components? (1 point)	☐ Yes ☒ No
Using the abbreviation 'Miller2008' as biblioid, indicate the information put into the field 'consolidated' in the worksheet 'bibliography''. (1 point)	Miller, K.L. 2008. 'Carotene content of local banana varieties in Wonderland'. International Journal of Food Composition (IJFC), volume 1 (1), pp. 1-20.
Indicate the sample documentation for 'Khan, raw' under sampleID S10 to be inserted into the worksheet 'sampling' in the different fields. If no information is available, put '-'. (4.5 points – ½ point for each correct response)	**sampleid**: S10 **fooditemid or name in source (put food codes only)**: 04001 (or 04002, 04003, 04004, 04005) **sampplan**: 20 bananas collected from Wonderland Island in 2007. Supposedly analysed in 2007. **sampdate**: 2007 **sampdesc**: Fi's banana, Musa troglodytarum var. Khan, yellow orange **sampcoll**: markets on Wonderland Island **sampfdnr**: 20 **sampwght**: - **biblioid**: Miller2008
Indicate the documentation for 'Khan, raw'. If no information is available, insert '-'. (4.5 points)	**foodname in English:** Banana, Khan, yellow-orange, raw **scientific name:** Musa troglodytarum L. var. Khan **source:** S10 **methodid of entire method for β-carotene:** M3 **methodid of entire method for water:** - **n:** 3 **sd (Khan for β-carotene):** - **min (Khan for β-carotene):** - **mean (Khan for β-carotene):** 2588
Indicate the tagnames of the analysed components in the bananas. (2.5 points)	**edible coefficient**: EDIBLE **β-carotene:** CARTB **α –carotene:** CARTA **β-crypto-xanthin**: CRYPX **Water**: WATER
Calculate VITA_RAE for the five foods in mcg (without decimal places) using retinol + CARTBEQ/12 (5 points)	**Banana, Jammy, yellow, raw:** 36 (= 0 + 432/12) **Banana, Than, yellow, raw:** 82 (= 0 + 806/12 + 360/24) **Banana, Than, yellow, boiled:** 95 (= 0 + 960/12 + 355/24) **Banana, Khan, yellow-orange, raw:** 268 (= 0 + 2588/12 + 1236/24 + 31/24) **Banana, Canot, orange, raw:** 705 (= 0 + 8455/12)

GENERAL FEEDBACK USING SELF-SCORING

Compilers and professional users should achieve the first two categories, whereas it is sufficient for analysts to achieve the last two.

136 – 180 points: You have understood well and integrated the issues on compilation and documentation. Congratulations. You are well prepared to apply the issues in your work.

91 – 135 points: You have understood and integrated most of the issues on compilation and documentation. This is very encouraging. You could improve your knowledge by returning to the sections where you did not obtain all possible points. You are advised to do so before being able to apply these issues in your work.

46 – 90 points: You have understood and integrated a fair part the issues on compilation and documentation. You should improve your knowledge by returning return to the sections where you did not obtain all possible points. It is highly recommended that you do so before being able to apply the issues. If you are an analyst working in a laboratory and not working on compilation, your knowledge seems to be already very good.

0 – 45 points: You appear to have significant gaps in your understanding of the issues on compilation and documentation. You should read the sections again and improve your knowledge of these topics before being able to apply the issues. If you are an analyst working in a laboratory and not on compilation, your knowledge may be sufficient.

Module 10.a

COMPARING FOOD COMPOSITION DATABASES

LEARNING OBJECTIVES

By the end of this module, the student should understand how to compare and use compositional data from different food composition databases.

EXERCISE MATERIAL

- FAO/INFOODS Compilation Tool version 1.2.1 (an Excel file available at http://www.fao.org/infoods/software_en.stm)
- From the United States Department of Agriculture (USDA) website http://www.ars.usda.gov/services/docs.htm?docid=8964, USDA SR22 abbreviated food composition database and nutrient definition file.
- From the Danish food composition website http://www.foodcomp.dk/v7/fcdb_default.asp, the Excel file of the Danish food composition database version 7.0 and the documentation
- From the United Kingdom food composition website http://www.food.gov.uk/science/dietarysurveys/dietsurveys/ McCance and Widdowson's Composition of Foods Integrated Dataset (CoF IDS) together with its documentation. Read *Details on Nutrient Data* (pp.4-7) and *Nutrient Definitions and Expressions* (pp.17-27) in the documentation (available at http://www.food.gov.uk/multimedia/pdfs/cofuserdoc.pdf).

REFERENCE MATERIAL

- Excel help available at http://office.microsoft.com/en-us/excel/FX100646951033.aspx

RECOMMENDATION

It is highly recommended that students complete this module after module 10.

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts

ESTIMATED TIME TO COMPLETE TASKS

- Completing the exercises: 3-8 hours

SAMPLE ANSWERS TO THE EXERCISES

Xa.E1 Compare the components in the Compilation Tool version 1.2.1 with those appearing in the USDA SR 22 comprehensive database and in the USDA abbreviated table. You will also need to consult the documentation of SR 22. Then answer the following questions. *(20 points)*

Note:

1. From the USDA website http://www.ars.usda.gov/services/docs.htm?docid=8964 download the USDA SR 22 abbreviated food composition database (click on 'download' and select 'Excel'), the documentation and the Nutrient definition file. The Nutrient definition file lists the tagnames and units for all components of the comprehensive database.
2. The Compilation Tool version 1.2.1 can be found at http://www.fao.org/infoods/software_en.stm. The component names in the Compilation Tool are tagnames. Their meanings and units can be found in the component worksheet (and are available at http://www.fao.org/infoods/tagnames_en.stm) and are explained in detail in module 4.b.

Answer:

Questions	Responses
Number of components that have different units between the SR 22 abbreviated table and nutrients in the Compilation Tool (2 points)	0
Number of components that have different units between the USDA SR 22 comprehensive database (as listed in the Nutrient definition file) and the corresponding components in the Compilation Tool (2 points)	20 (vitamin D and amino acids)
Indicate the components that are in both the USDA SR 22 comprehensive database and in the Compilation Tool but are not in the abbreviated USDA table. (3.5 points)	☐ ENERC (kJ) ☒ Individual sugars ☐ FIBTG ☐ NA ☒ Individual amino acids ☒ Individual fatty acids ☐ FAMS
What should be done to access the additional components of the comprehensive database with their values? List two options. (2 points)	1. Download the nutrient data file containing the comprehensive database and covert it from txt to Excel 2. Download ASCII or Access files containing the comprehensive database
Select the components that are <u>not</u> in the USDA SR 22 comprehensive database but are in the Compilation Tool. (3.5 points)	☒ NT ☐ FAT ☒ CHOAVLDF ☒ ADSUGAR ☐ CA ☒ ID ☒ VITD (mcg)
Where is the information about the number of decimal places located in the USDA nutrient definition file? (1 point)	After the component name at the fifth position
Where are the nutrient definitions indicated for the USDA SR 22? (1 point)	In the documentation document
For the USDA SR 22, where are the analytical methods for the components indicated? (1 point)	In the documentation document
For some of the fatty acids of USDA SR22, it is difficult to decide whether or not they are the same as those in the Compilation Tool. For example: Is 22:5 n-3 (F22D5) in USDA SR 22 the same as F22D5CN3? What should a user do to know if they really are the same? Select the correct answer by ~~striking through those that are wrong~~. (1 point)	~~- Assume that they are the same because there is no trans form~~ ~~- Assume that they are different because there is a trans form~~ - Write and ask USDA
List two of the nutrients in the USDA database that could cause problems for untrained users because of their name, definition or unit. (2 points)	Your answer should include any two of the following: - Vitamin A (because in RAE and IU while other databases use RE) - Vitamin D (as in IU while other databases use mcg) - Folate (not all users may know which value to choose and values are different due to method and expression) - Carbohydrates (not all users may notice that these are total carbohydrates which have different values compared to CHOAVL) - Amino acids (because in g) - Vitamin E (not all users may notice that it is only α-tocopherol)

Which database should be downloaded by a compiler interested in individual fatty acids and amino acids: the abbreviated or the comprehensive database of USDA SR 22? ~~Strike though the incorrect one~~. (1 point)	~~Abbreviated/~~comprehensive database

<u>For your information</u>:
In USDA SR 22, values for XN are available but are stored in the food description file. Data will need to be extracted from that file. In USDA SR 22, Vitamin D is listed with IU and in mcg. In SR 21 and previous releases, vitamin D has only the unit IU, which can be converted into mcg using the following formula: 1 IU vitamin D = 0.025 mcg vitamin D_3. For those who are not interested in individual fatty acids and amino acids (and the other components only available in the comprehensive database), it is more convenient to download the abbreviated database.

Xa.E2 Compare the components in the Compilation Tool with those in the Excel file of the Danish food composition database version 7.01. Then answer the following questions. *(7 points)*

<u>Note</u>:
1. The Danish food composition database version 7.01 and its documentation are available at http://www.foodcomp.dk/v7/fcdb_default.asp. For downloading the Excel file choose 'download food data' and then 'Excel file'. The components are listed in the worksheet 'komponenter'. Additional information can be found at the Danish food composition database website under 'About food data' (click on this icon in upper left-hand corner of website to access the documentation), especially on nutrient definitions.
2. The Compilation Tool can be found at http://www.fao.org/infoods/software_en.stm. The component names in the Compilation Tool are tagnames. Their meanings and units can be found in the component worksheet and at http://www.fao.org/infoods/tagnames_en.stm and are explained in detail in module 4.b.

Answers:

Questions	Responses
Number of components that have different units between the Danish database and nutrients in the Compilation Tool. (2 points)	0 (all components have the same unit but they may have different definitions and expressions – see below)
Where is the information about the number of decimal places located for the Danish database? (1 point)	Nowhere, as they are not standardized
Where are the nutrient definitions of the Danish database indicated? (1 point)	In the documentation on the website under 'About food data' (some information is also given in the worksheet 'komponenter')
For the Danish database, where are the analytical methods for components indicated? (1 point)	In the documentation on the website under 'About food data'
List two of the nutrients in the Danish database that could cause problems for untrained users because of their name or definition. (2 points)	Your answer should include any two of the following: • Fat (not known which method) • Vitamin A (because it is RAE but named RE) • β-carotene (because it is in β-carotene equivalent) • Vitamin D (different definition from most other databases: sum of vitamin D_2 + vitamin D_3 + 5 x 25-hydroxyvitamin D; the latter is mainly present in pork) • Fatty acids (as the fatty acid names are different from the systematic names (often 'cis' is indicated in the systematic name in 'about food data' but not in fatty acid name in the database) • Possible confusion between dietary fibre and Dietary fibre, total (AOAC) • Possible confusion between Niacin and niacin (the first is niacin equivalent; the second is niacin only)

Xa.E3 Put the nutrients of the Danish food composition database version 7.01 into the same order as in the Compilation Tool version 1.2.1. Check that all units are the same as those in the Compilation Tool. If necessary, change all nutrient values to the unit as expressed in the Compilation Tool. *(26 points: ½ point for each correct response)*

The objectives of this exercise are to improve your knowledge of component nomenclature and enable you to easily borrow nutrient values in the event you wish to do so.

<u>Note</u>:
- For those not very familiar with Excel you might find it helpful to consult 'Excel help' available at http://office.microsoft.com/en-us/excel/FX100646951033.aspx
- The Danish food composition database version 7.01 and their documentation are available at http://www.foodcomp.dk/v7/fcdb_default.asp. For downloading the Excel database choose 'download food data" and then 'Excel file'. The components are listed in the worksheet 'komponenter'. Additional information can be found at the Danish food composition database website under 'About food data' (click on this icon in upper left-hand corner of website to access the documentation), especially on nutrient definitions.
- The Compilation Tool can be found at http://www.fao.org/infoods/software_en.stm. The component names in the Compilation Tool are tagnames. Their meanings and units can be found in the component worksheet and at http://www.fao.org/infoods/tagnames_en.stm and are explained in detail in module 4.b.

<u>Instructions to change the order of nutrients in the Excel file of the Danish food composition database</u>:
1. Attribute tagnames to all components of the Danish database.
2. Open in two Excel applications (not in two windows of the same Excel application) the two files 'Compilation Tool version 1.2.1.xls' and the Danish food composition database version 7.01. Minimize them. Then arrange the two windows so that you can see them together on the screen (one above the other).
3. Cut and insert (not paste!! as paste would overwrite existing data) the different columns into the right order.
    a. Move columns with same nutrient definition to the corresponding column in the Compilation Tool
    b. Insert a blank column when the nutrient is not available in the Danish file.
    c. Move the columns with those components not present in the Compilation Tool to the end of the file (do not delete them as you might wish to use them at a later stage).
4. You can use button F4 to repeat the last task, e.g. to insert a column.
5. Check whether you have put the columns in the right place:
    a. insert into the Danish file a row before row 1
    b. copy the tagnames (e.g. from reference database worksheet) starting with DEN until the last tagname
    c. paste the copied tagnames into the inserted row in the Danish file
    d. Change order if necessary and check again.
6. Create a new worksheet and put all unused components into it together with the columns 'food codes' and 'food names'. Pay attention that the food names and codes are on the same lines as their corresponding values.

Congratulations

Now verify that you have made the transformation correctly by putting into the table below the English and Danish component names corresponding to the listed component names of the Compilation Tool. If there is no correspondence, put a dash '-'.

Answer:

Component name in Compilation Tool	Corresponding English component name in Danish database	Corresponding Danish component name in Danish database
ENERC(kcal) (standardized)	-	-
WATER(g)	Moisture	Vand
XN	-	-
PROCNT/PROT(g)	Protein, total	Protein, total
FASAT(g)	Saturated fatty acids	mættede fedtsyrer
CHOAVLDF(g)	Carbohydrate, total	Kulhydrat, total
CHOAVLM(g)	-	-
FIBTG(g) AOAC	Dietary fibre, total (AOAC)	Kostfibre, total (AOAC)
PSACNS(g) NSP	-	-
FIB – (g)	Dietary fibre	Kostfibre
ASH(g)	Ash	Aske
CA(mg)	Calcium, Ca	Calcium, Ca
SE(mcg)	Selenium, Se	Selen, Se
ID(mcg)	Iodine, I	Jod, I
VITA_RAE(mcg) (standardized)	-	-
VITA_RAE(mcg)	Vitamin A	A-vitamin
VITA(mcg)	-	-
CARTBEQ(mcg)	ß-carotene eq.	ß-caroten
CARTB(mcg)	-	-
VITD(mcg)	-	-
FOL(mcg) (standardized)	-	-
FOL	Folates	Folat
FOLFD(mcg)	-	-
NIAEQ(mg)	Niacin equivalents	Niacin
F18D1CN7(g)	C 18:1, cis n-7	C 18:1, n-7
LEU(mg)	Leucine	Leucin

For your information:
When copying values from other sources, all 'standardized' component values should remain empty in the archival database as it contains only the original data. The standardized component values should be completed only in the reference database. Some component names in the Danish database provide different information in Danish than in English (e.g., indication of cis in fatty acids or equivalent for ß-carotene or niacin.

If you wish to put the abbreviated table of USDA SR 22 into the same format as in the Compilation Tool, you will need to consult the Nutrient definition file because it lists the tagnames and units for all components. Instructions to change the order of nutrients in the USDA SR 22 abbreviated table are the same as for the Danish table. In addition, you have to change refuse into edible portions as follows:

Write EDIBLE in the row of the nutrient names (at the same column as in the Compilation Tool) and then transform the refuse values ('Refuse_Pct at the end of the file in column CU) into edible coefficient.

a. Put the formula into the EDIBLE cell of the first food '=(100-CU2)/100' (if = is forgotten in front, the formula does not work);
b. Copy the formula to all foods
c. Copy this column
d. Paste the column EDIBLE into the same column using PASTE SPECIAL – Value to transform the formulas into values.

This is an excellent exercise to practice knowledge of component nomenclature.

Xa.E4 Compare the components in the Compilation Tool with those in the British food composition database 'McCance and Widdowson's Composition of Foods Integrated Dataset' (CoF IDS). Then answer the following questions (6 points)

Note:

- The 'McCance and Widdowson's Composition of Foods Integrated Dataset' (CoF IDS) is available at http://www.food.gov.uk/science/dietarysurveys/dietsurveys/ together with its documentation. Read the sections *Details on Nutrient Data* (pp.4-7) and *Nutrient Definitions and Expressions* (pp.17-27) in the documentation (available at http://www.food.gov.uk/multimedia/pdfs/cofuserdoc.pdf). Some of the nutrients were already matched to tagnames in IVb.E4.
- The Compilation Tool is available at http://www.fao.org/infoods/software_en.stm. The component names in the Compilation Tool are tagnames; their meanings and units can be found in the component worksheet and at http://www.fao.org/infoods/tagnames_en.stm and are explained in detail in module 4.b.

Answer:

Questions	Responses
Number of units that are different between the British table and the nutrients in the Compilation Tool (2 points)	0
Where are the nutrient definitions indicated for the British database? (1 point)	In the documentation file
For the British database, where are the analytical methods for the components indicated? (1 point)	For some, they are in the documentation file; for others, they are not indicated (e.g. fat)
List two of the nutrients in the British database that could cause problems for untrained users because of their name or definition. (2 points)	Your answer should include any two of the following: • Fat (not known which method) • All carbohydrates (because their values are all in monosaccharide equivalents – CHOAVLM- and are therefore higher than CHOAVL. See module 4.b for more information). • Dietary fibre (because Englyst method values – PSACNS/NSP - are mostly lower that AOAC values - FIBTG; only few AOAC values are available) • β-carotene (because it is β-carotene equivalent) • Vitamin D (different definition from most other databases: sum of vitamin D_2 + 5 x 25-hydroxyvitamin D; the latter is mainly present in pork.)

For your information:
More information on recipes and analytical methods is given in the book 'McCance and Widdowson's Composition of Foods' - sixth edition than in 'McCance and Widdowson's Composition of Foods Integrated Dataset' (CoF IDS), such as recipe calculation methods and nutrient retention and yield factors, etc.

GENERAL FEEDBACK USING SELF-SCORING

46 – 59 points: You have understood well and integrated the issues on comparison of food composition databases. Congratulations. You are well prepared to apply the issues in your work.

31 – 45 points: You have understood and integrated most of the issues on comparison of food composition databases. This is very encouraging. You could improve your knowledge by returning to the sections where you did not obtain all possible points. You are advised to do so before being able to apply these issues in your work.

16 – 30 points: You have understood and integrated a fair part of the issues on comparison of food composition databases. You should improve your knowledge by returning return to the sections where you did not obtain all possible points. It is highly recommended that you do so before being able to apply the issues. If you are an analyst working in a laboratory and not on compilation, your knowledge is already very good.

0 – 15 points: You appear to have significant gaps in your understanding of the issues on comparison of food composition databases. You should read the sections again and improve your knowledge of these topics before being able to apply the issues. If you are an analyst working in a laboratory and not on compilation, your knowledge might be sufficient.

Module 10.b

CASE STUDY - TRANSLATING FOOD INTAKE INTO NUTRIENT INTAKES

LEARNING OBJECTIVES

By the end of this module, the student will be able to calculate nutrient intake estimations and appreciate difficulties in selecting appropriate foods from a food composition database or table to obtain high-quality results.

RECOMMENDATION

This is a case study to apply the newly acquired knowledge in food composition. The learner will choose a diet and a food composition database to translate the food into nutrient intakes. This exercise is like a real-life situation where the most suitable food records have to be identified and then be applied. The learner will encounter many difficulties and may have to go back to some modules or learning material. It is however highly recommended that this exercise be completed in groups and results discussed among learners. This module should be completed after module 10 and 10.a.

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts

ESTIMATED TIME TO COMPLETE TASKS

- Completing the exercises: 3-10 hours

ANSWERS TO THE EXERCISES

There are no answers to the exercises as all results depend on individual choices of foods and the food composition database.

Guidance for responses

Pay attention when:

- describing your foods (see module 3)
  - Be comprehensive in the food description.
  - For example, 'low fat milk' is too vague. 'Milk, cow, low fat, 1.5 % fat, pasteurized' is better.
- matching foods (see modules 3 and 10)
  - Be careful to select the closest foods in the food composition tables to yours.
  - Food matching is key to the quality of the nutrient intake estimations.
- copying values to match correct component and unit plus denominator (see modules 4.b, 4.c, and 10)
- calculating recipes (see module 8)
- compiling data (see modules 10, 10.a and 11)
  - Frequently re-check your values for consistency and errors.
  - Errors are easy to introduce.

EXERCISES

XI.E1 Calculate the nutrient intake estimations for the selected diet following the instructions below.

1. The diets below represent the results of a national food consumption survey carried out with a food frequency questionnaire (FFQ). Select one.

European diet		Rice-based diet		Maize-based diet	
Foods	Consumption in g per day	Foods	Consumption in g per day	Foods	Consumption in g per day
-Pasta or rice	60	-Rice	200	-Maize (porridge, etc)	80
-Mixed-grain bread	50	-Potatoes	20	-Bread (maize, wheat etc.)	50
-White bread (buns, rolls, etc)	50	-Vegetables (fresh or as a side dish)	200	-Potatoes and other tuber (cassava, taro etc)	100
- Wholemeal bread	20	-Fruit, fresh	80	-Vegetables (fresh or as a side dish)	100
-Potatoes	50	-Stewed fruit, fruit sauce, etc	5	-Fruit, fresh	80
-Vegetables (fresh or as a side dish)	100	-Milk, and other milk drinks	30	-Stewed fruit, fruit sauce, etc	5
-Fruit, fresh	80	-Milk products (cheese, yoghurt, etc.)	5	-Milk, and other milk drinks	30
-Stewed fruit, fruit sauce, etc	20	-Beef or pork	20	-Milk products (cheese, yoghurt, etc.)	30
-Milk, and other milk drinks	300	-Poultry	30	-Beef or pork	30
-Milk products (e.g. cheese, yoghurt)	40	-Fish	50	-Poultry	50
-Beef or pork	100	-Eggs	30	-Fish	30
-Poultry	50	-Pulses (beans, lentils, etc.))	60	-Eggs	20
-Processed meats (sausages, etc.)	80	-Almonds, peanuts or nuts	50	-Pulses (beans, lentils, etc.))	50
-Fish	30	-Butter, vegetable oils	30	-Almonds, peanuts or nuts	20
-Eggs	50	-Pastries	10	-Butter, vegetable oils	40
-Pulses (beans, lentils, etc.)	10	-Chocolate, confectionery	10	-Pastries	10
-Almonds, peanuts or nuts	20	-Savoury snacks (e.g. Chips)	30	-Chocolate, confectionery	5
-Butter, vegetable oils	50	-Fruit or vegetable juices	20	-Savoury snacks (e.g. Chips)	10
-Pastries	50	-Soft drinks etc	20	-Fruit or vegetable juices	20
-Chocolate, confectionery	30	-Tee (black, fruit, green tea)	200	-Soft drinks etc	200
-Savoury snacks (e.g. chips)	30	-Water	300	-Tee (black, fruit, green tea)	100
-Fruit or vegetable juices	150	-Alcoholic beverages	20	-Coffee	20
-Soft drinks etc	250			-Water	300
-Tee (black, fruit, green tea)	20			-Alcoholic beverages	50
-Coffee	20				
-Water	200				
-Alcoholic beverages	20				

2. For the chosen diet, select for each reported food the three foods that best represent the FFQ foods. Later on these three foods will be matched with foods in food composition tables (i.e. to borrow their nutrient values) and then to calculate nutrient intake estimations. For example: for the FFQ food 'Pasta or rice', the foods 'boiled white spaghetti', 'baked lasagne with meat sauce' and 'boiled white rice' were chosen to best represent the FFQ food.

3. Select a food composition database as the primary source of data (preferably the national food composition database) and decide which other databases or literature sources to use in case the data are not found in the primary source.

4. Decide which nutrients and components to include in your food composition database. Select nutrient definition, unit and denominator for all components. Match them to tagnames. You may also decide to take all components indicated in the Compilation Tool version 1.2.1 for your database. See module 4.a for more information.

5. Match components from the different compositional data sources to INFOODS tagnames.

6. Decide on a food grouping system and classify all FFQ foods with their three corresponding foods (e.g. 'boiled white spaghetti') within the system. See module 3 for more information.

7. Copy the Compilation Tool version 1.2.1 from the INFOODS website (http://www.fao.org/infoods/SOFTWARE/compilation%20tool%20version1.2.xls) and save it on to your computer. Do not delete or change the order of components. If you need to add components, do so at the end of the list. In the user database, you can insert them into the position you wish.

8. In the worksheet 'archival database', enter all FFQ foods and corresponding foods within the food groups. Add a code, a record number and type. See module 10 for more information.

9. In the worksheet 'archival database' of the Compilation Tool, match the foods (e.g. 'boiled white spaghetti') to foods in the food composition database. Allocate 1 for exact match, and 2 for similar match. Document the data by indicating 'source' and 'fdnumber of source' in the corresponding fields. (**Option for those with limited time availability**: select three FFQ foods and their corresponding nine foods and continue the remaining tasks with them.)

10. In the worksheet 'archival database', copy the nutrient values of the foods from the data source into the corresponding fields of the foods representing the FFQ foods. See in module 10.a how to change the order of components and to compare them to an existing set of components.

11. Copy all completed lines from the 'archival database' into the worksheet 'reference database'. Add a line below each food to add additional documentation. Now aggregate data, complete missing data, estimate or impute data, calculate energy and other equivalents, etc. Complete the 'standardized' nutrients. Check data for consistency and plausibility. See modules 8 and 10 for more information.

12. If necessary, calculate the nutrient values of recipes or cooked foods in the worksheet 'recipe calculation'. If necessary, in the worksheet 'recipe+ingredients', transform weights of raw foods with inedible parts into the weight of the raw edible food. Recipe calculation should start only when all ingredients have a complete set of nutrient values which were also checked for consistency. If any recipe ingredient is missing in the database, add it first in the 'archival database' then into the 'reference database' and complete and check all values of the ingredient (as listed under points 9-11). Once the recipe calculation has been completed and the values checked, copy the final nutrient values of the recipe into the 'reference database'. See module 8 for more information.

13. Decide on a weighing factor for the three foods per FFQ food. For example: For the FFQ food 'Pasta or rice' (60 g/d), the equal weighing factors were chosen because an similar consumption is assumed in the population: 33% (=20 g/d) 'boiled white spaghetti', 33% (=20 g/d) 'baked lasagne with meat sauce', and 33% (=20 g/d) 'boiled white rice'.

14. Calculate the nutrient intake estimations for the selected nutrients.

Module 11

QUALITY CONSIDERATIONS IN DATA COMPILATION

LEARNING OBJECTIVES

By the end of this module the student will be able to:

- understand the principles of quality assessment and their importance in the compilation process;
- apply them when collecting and compiling compositional data for food composition databases.

REQUIRED READING

- **Greenfield, H. & Southgate, D.A.T.** 2003. *Food composition data – production, management and use*. FAO, Rome. Chapter 10 (pp. 174-178, 183-186 of the book, not of the PDF file). The PDF file of this book is available at the INFOODS website: ftp://ftp.fao.org/docrep/fao/008/y4705e/y4705e00.pdf
- **EuroFIR**. 2007. EuroFIR Workpackage 1.3, Task group 4. Guidelines for quality index attribution to original data from scientific literature or reports for EuroFIR data interchange. Draft document. Available at: HTTP://WWW.EUROFIR.ORG/EUROFIR/DOWNLOADS/VALUEDOCUMENTATION/QI_GUIDELINES_DRAFT_TESTVERSION300707.DOC

EXERCISE MATERIAL

- **EuroFIR**. 2008. Excel file containing questions on the seven quality evaluation categories accessed in 2008: http://www.eurofir.org/eurofir/Downloads/ValueDocumentation/ValueDocumentation_QATemplates_July07.xls
- **Westenbrink, S., Oseredczuk, M., Castanheira, I. & Roe, M**. 2008. Food composition databases: The EuroFIR approach to develop tools to assure the quality of the data compilation process. *Food Chemistry*, doi:10.1016/j.foodchem.2008.05.112. The article may be ordered though http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T6R-4SRCJVP-5&_user=6718006&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000055286&_version=1&_urlVersion=0&_userid=6718006&md5=91eda33285385a8161457319abba68be
- **Holden, J.M., Bhagwat, S.A. & Patterson, K.Y.** 2002. Development of a multinutrient data quality evaluation system. *Journal of Food Composition and Analysis* 15(4), pp. 339–348. Available at: http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%236879%232002%23999849995%23341462%23FLP%23&_cdi=6879&_pubType=J&_auth=y&_acct=C000055286&_version=1&_urlVersion=0&_userid=6718006&md5=c50ea9203aa7a0b2dce40ca403eaf868

LITERATURE QUOTED IN QUESTIONS AND EXERCISES

- **Klensin J., Feskanich, D., Lin, V., Truswell, S.A. & Southgate, D.A.T**. 1989. *Identification of Food Components for INFOODS Data Interchange*. UNU, Tokyo. Available at: http://www.unu.edu/unupress/unupbooks/80734e/80734E00.htm or as PDF at ftp://ftp.fao.org/es/esn/infoods/Klensinetal1989Identificationoffoodcomponents.pdf
- **Truswell, S.A., Bateson, D.J., Madafiglio, K.C., Pennigton, J.A.T., Rand, W.M. & Klensin, J.C.** 1991**.** Committee Report: INFOODS - Guidelines for describing Foods: A Systematic Approach to Describing Foods to Facilitate International Exchange of Food Composition Data**.** *Journal of food composition and analysis* 4, 18-38. Available at**:** http://www.fao.org/wairdocs/AD069E/AD069E00.HTM
- **Schlotke, F., Becker, W., Ireland, J., Møller, A., Ovaskainen, M.L., Monspart, J. & Unwin, I.** 2000. Eurofoods recommendations for food composition database management and data interchange. Report No. EUR 19538. *Office for Official Publications of the European Communities, Luxembourg*. Available at: ftp://ftp.fao.org/ag/agn/infoods/EurofoodsRecommendations.pdf
- The LanguaL food description system http://www.langual.org/: its use, thesaurus, and further literature.
- **Castanheira, I., Robb, P., Owen, L., den Boer, H., Schmit, J., Ent, H., Calhau, M.A.** 2007. A proposal to demonstrate a harmonized quality approach to analytical data production by EuroFIR. *Journal of Food Composition and Analysis*, 20, pp. *725-732*. Available at http://www.sciencedirect.com/science?_ob=PublicationURL&_cdi=6879&_pubType=J&_acct=C000055286&_version=1&_urlVersion=0&_userid=6718006&md5=025a00d3fb8e5e6666bdc4983483ca9c&jchunk=20#20

RECOMMENDATION

It is highly recommended that students complete modules 1 and 3-10 before starting on the present module.

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts ++

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1-3 hours
- Answering the questions: 1-3 hour
- Completing the exercises: 1-3 hour

SUGGESTED ADDITIONAL READING

- **Castanheira, I., Roe, M., Westenbrink, S., Ireland, J., Møller, A., Salvini, S., Beernaert, H., Oseredczuk, M. & Calhau, M.A.** 2009. Establishing quality management systems for European food composition databases. *Food Chemistry* Volume 113, Issue 3, 1 April, pp. 776-780. doi:10.1016/j.foodchem.2008.05.091. The article may be ordered though http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T6R-4SNGMB7-B&_user=6718006&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000055286&_version=1&_urlVersion=0&_userid=6718006&md5=336901caae408d852ad71afbfdc1ff3f
- **Burlingame, B.** 2004. Fostering quality data in food composition databases: visions for the future. *Journal of Food Composition and Analysis* Volume 17, Issues 3-4, pp. 251-258. Available at http://www.sciencedirect.com/science/article/B6WJH-4CG7FR0-2/2/1ba833ea69c95f2c70b26cdd1a429d98
- **Harrison, G.G.** 2004. Fostering data quality in food composition databases: applications and implications for public health. *Journal of Food Composition and Analysis* Volume 17, Issues 3-4, pp. 259-265. Available as above.

Answers to the questions

XI.Q1 What is the purpose of assigning quality codes to food composition data? Select True or False. *(4 points: ½ point for each correct response)*

Answer (Greenfield and Southgate, 2003, p. 183; EuroFIR, 2007, pp. 1-3):

Quality codes are assigned to food composition data in order to:	True	False
indicate the overall quality of analytical data points, including for data interchange.	x	
assess the quality of data obtained from the scientific literature and laboratory reports.	x	
assess the quality of data that are borrowed, imputed, calculated or estimated in the food composition database.		x
provide a formalized approach to assist compilers to accept or reject data for inclusion in a food composition database.	x	
assist compilers revising low-quality data.	x	
show users which data points are more reliable than others.	x	
motivate compilers to adopt high-quality compilation procedures.	x	
provide information to data generators and compilers for prioritizing foods and nutrients for new analysis.	x	

For your information:
Borrowed, imputed, calculated or estimated food composition data are not normally assessed using a formal quality assessment system. Often, their source codes, which identify them as borrowed, imputed, calculated or estimated, are used to indicate that they should be of a lower quality.

EuroFIR intended working on a quality assessment system for borrowed, imputed, calculated or estimated data. The current quality assessment system described by EuroFIR (2007) states that it is only applicable to data of analytical origin (scientific literature and laboratory reports, etc.).

XI.Q2 Data quality can be assessed in a meaningful manner only when certain requirements are fulfilled (e.g. data documentation). Otherwise, all or most data would receive a low-quality score. From the following list, select those elements needed to assess the quality of food composition data. Select True or False. *(4 points: ½ point for each correct response)*

Answer:

Elements needed to assess the quality of the food composition data	True	False
Value documentation	x	
Comprehensive information on the food and component nomenclature used	x	
Compilation software that has features to support documentation and facilitates the quality assessment of data	x	
Written guidelines on the data quality assessment procedure, including criteria and/or advice for compilers to decide on the inclusion or exclusion of data	x	
Food consumption data		x
Written guidelines on laboratory quality assurance schemes		x
Metadata of food composition data	x	
Staff time	x	

For your information:
Proper documentation of food composition data is essential, otherwise it is impossible to apply a quality assessment system in a satisfactory manner.

Quality considerations regarding food composition database management software/hardware are still missing but it would be useful to stimulate compilers to either seek high-quality software packages or upgrade their compilation software, e.g. with user-friendly functions to assess the quality of data and the compilation process, or which would include common computer security issues (e.g. quality/security measures for the back-up of databases; access rights to the database; server location access control; and firewall).

Written guidelines on laboratory quality assurance schemes are necessary to obtain high-quality analytical data but not for judging the quality of compositional data. The quality aspects of analytical data are dealt with in module 6.

XI.Q3 **Match the definitions with the corresponding terms.** *(3.5 points: ½ point for each correct response)*

<u>Terms</u>:
1. Confidence code (CC)
2. Evaluation category
3. Evaluation criteria
4. Quality index (QI)
5. Data quality assessment (evaluation) system
6. Quality
7. Source code

Answer (Greenfield and Southgate, 2003, pp. 174-176, 183-185; EuroFIR, 2007, pp. 3-5):

Definitions	Term number
It is a systematic approach to evaluating data quality in accordance with common guidelines and criteria, and subsequently expressing data quality in a standardized and coherent manner.	5
It corresponds to one topic or theme divided into a series of criteria.	2
It indicates the origin/source of the data point, which is sufficient to indicate the quality of the calculated or estimated data. It can be used as an indicator of data quality.	7
It represents the totality of characteristics of an entity (product or service) that are able to satisfy stated and implied needs.	6
It is expressed in numerical values used to judge whether a component value is likely to represent the real content in a food (e.g. in a given country). These values derive from the points achieved in the evaluation process and which the compiler will transform into the confidence codes for users.	4
This expresses the overall trust that the compiler has in the data. It is usually in letter form, and is intended to guide users of food composition databases on the quality of their data. For example, A = high; B = moderate; C = low.	1
These are specific topics (often formulated as questions) used to assess the data quality within a category. Ideally, they should be clear and objective and accompanied by possible answers such as: yes, no, unknown or non applicable. Sometimes they are broad statements with answers such as: well done, less clear, no information or incorrect application. Points can be achieved through the answers and will be summarized to build the confidence codes and then the quality index.	3

XI.Q4 **For each of the four data scrutiny considerations or quality assessment systems given below, select the evaluation criteria included.** *(22 points: ½ point for each correct response)*

Answer (Greenfield and Southgate, 2003, pp. 174-176, 183-185; EuroFIR, 2007, pp. 3-5):

Criteria	Confidence codes (Exler, 1982)*	USDA data evaluation system (Holden *et al.*, 2002)*	Data scrutiny considerations (Greenfield and Southgate, 2003)	EuroFIR quality index (EuroFIR, 2007)
Food identification			x	x
Component identification				x
Unit and denominator			x	x
Sampling plan		x	x	x
Number of independent analytical samples		x		x
Sample handling in laboratory	x	x	x	x
Validity of analytical method	x	x	x	x
Analytical quality control/assurance	x	x	x	x
Uses broad statements per criteria	x		x	
Uses specific questions per criteria		x		x

* cited in Greenfield and Southgate, 2003

<u>**Interpretation**</u>**:**
Match each data quality evaluation systems or considerations to the corresponding responses.

<u>Data quality evaluation systems or considerations</u>:
1. Confidence codes (Exler, 1982)
2. USDA data evaluation system (Holden *et al.*, 2002)
3. Data scrutiny considerations (Greenfield and Southgate, 2003)
4. EuroFIR quality index (EuroFIR, 2007)

	The evaluation system or consideration covers:
4	most aspects influencing the quality of data
1	analytical aspects only
2	analytical and sampling aspects
3	analytical and sampling aspects, and food identification

<u>For your information</u>:
Although the unambiguous, correct identification of foods, components and values (units and denominators) is considered of key importance for interchange of food composition data (Klensin *et al.*, 1989; Truswell *et al.*, 1991, Schlotke *et al.*, 2000; LanguaL, 2008), the early quality schemes (Exler, 1982, and Holden *et al.*, 2002) did not include these important aspects. The identification of foods, components and values in addition to the sampling and analytical aspects are included in the proposed EuroFIR quality evaluation system (see EuroFIR, 2007). EuroFIR and Holden *et al.*, 2002, have also included specific questions, with a certain number of points to be obtained per category (criteria), in order to make a standardized and objective data assessment possible. The data assessment systems and considerations were developed consecutively and each builds and expands upon the previous versions.

XI.Q5 Match the following criteria to the corresponding evaluation category. These are derived from the EuroFIR guidelines for quality index attribution. *(13.5 points: ½ point for each correct response)*

Note:

- The principles of food and component identification, sampling and quality aspects of analytical data should be understood before attempting to answer the following questions. These principles are explained in modules 3, 4.b, 5 and 6.
- The EuroFIR guidelines for quality index attribution are available at: HTTP://WWW.EUROFIR.ORG/EUROFIR/DOWNLOADS/VALUEDOCUMENTATION/QI_GUIDELINES_DRAFT_TESTVERSION300707.DOC.

Evaluation categories:
1. Food description
2. Component identification
3. Sampling plan
4. Number of analytical samples
5. Sample handling
6. Analytical method
7. Analytical performance

Answer:

Evaluation category	Evaluation criteria
7	Was an appropriate number of analytical replicates used?
2	Are the definitions, calculation modus and expression provided?
1	Was the food or main ingredient documented in sufficient detail (including, if relevant, the scientific name with variety, species and cultivar)?
1	Was the part of plant or part of animal clearly indicated?
5	Were the samples protected from food composition changes brought about by heat, air, light or microbiological and enzymatic activity?
3	Was the number of primary samples more than nine? Was more than one brand (for manufactured prepacked products), cultivar (for plant foods) or subspecies (for animal foods) sampled, and are brands, cultivars and subspecies relevant?
1	Was the complete name and description of the recipe provided?
6	Did the analytical method used match the guidelines on an appropriate method for the component?
5	Were the samples protected from microbiological, enzymatic or chemical contamination (metallic blades, milling equipment, glassware, etc.)?
1	Was the edible portion described, and is it stated explicitly whether the food was analysed with or without the inedible part?
4	Was the number of analytical samples more than five?
3	Was the sampling plan developed to represent consumption in the country where the study was conducted?
5	Was any treatment for stabilization necessary (freeze-drying, adding of anti-oxidant, etc.), and was it applied?
1	Was the physical state, shape or form indicated (solid, semi-solid, liquid, ground, with pulp, etc.)?
7	Was the laboratory accredited for this method, or was the method validated by performance testing?
1	If the food was cooked, were full details of the cooking method provided?
4	Was the number of analytical samples more than one and fewer than five?
5	Were storage and transportation times adequate to preserve the level of the analyte?
7	Was an appropriate certified reference material or a standard reference material used?
1	Was the moisture content of the sample measured and the result given?
2	Does the component, as described in the publication, match the component as described in the databank?
3	Were samples taken during more than one season? Is (are) the season(s) of sampling relevant?
3	Were samples taken from more than one geographical location and/or sales outlet?
4	Was the number of analytical samples one?
5	Were the samples homogenized?
2	Were the unit and the denominator (i.e. matrix unit) unequivocal?
6	Were the key method steps appropriate to describe the analytical method?

For your information:
More information on sampling is found in module 5 (e.g. on primary samples, sample plan, sample handling) and in module 6 on quality aspects of analytical data (e.g. replicates, analytical samples, choice of method, quality assurance).

Details of the water content help to verify the food description. For example, a low water content indicates that the food is dried or in powder form. High water content, however, does not necessarily distinguish between different cooking and preservation methods. More descriptors are needed to fully describe the food.

XI.Q6 Data scrutiny and quality assessment schemes should be robust, i.e. different users applying the same criteria to the same data should come to the same (or similar) results. Select the procedure that is the most robust data scrutiny and quality assessment scheme. *(1 point)*

Answer:

Robustness of data scrutiny and quality assessment scheme	Most robust
Quality is established based on subjective allocation of points per criteria (e.g. 2-9 points, depending on details of food description).	
Quality is established based on criteria with objective questions and a well-defined, standardized way of allocating points, i.e. each criterion is accompanied both by a set of specified conditions to attribute points and by a thesaurus for terms.	x
Quality is established based on objective questions with a subjective allocation for overall scoring per question.	
Quality is established based on criteria with questions that may be interpreted in different ways by different users.	

For your information:
It is difficult to develop a robust data scrutiny and quality assessment scheme that: (i) is applicable to all analytical data; (ii) efficiently distinguishes between different data quality (e.g. by means of the confidence codes); and (iii) provides objective and reproducible results. An objective method that uses precise criteria and an allocation of points is therefore more robust than a subjective judgement and subjective allocation of points.

In any assessment scheme, if questions are interpreted differently by users, they should be changed to make them clearer and less ambiguous. Or, if users regularly ask questions on issues that are not covered by existing criteria, it might be necessary to add new criteria or categories.

XI.Q7 Some quality assessment systems explicitly exclude data obtained from the calculation, borrowing, imputation and estimation. Indicate from the following list the elements which should be included in a data quality assessment system to assess the quality of data derived from recipe calculations, borrowing, imputation and estimation. Select True or False. *(7.5 points: ½ point for each correct response)*

Answer:

Elements needed for data quality assessment of recipe calculations	True	False
Quantity and description of all ingredients	x	
Quality indication of yield and nutrient retention factors for cooked recipes	x	
Recipe name and brief description of preparation steps that have an impact on nutrient values	x	
All detailed cooking instructions as provided in recipe book (e.g. cut into 2 cm strips and leave to cool for two hours)		x
Quality indication of nutrient values of ingredients	x	
Standardized application of yield and nutrient retention factors for cooked recipes	x	
Bibliographic reference of the recipe (e.g. recipe book)	x	
Written procedure on analytical methods		x
Sampling of ingredients		x
Written guidelines on the quality assessment scheme for data derived from recipe calculations	x	

Elements needed for data quality assessment for borrowing, imputation and estimation of values	True	False
Assurance that foods are the same or as similar as possible	x	
Assurance that laboratory quality assurance schemes are applied to calculated data		x
Assurance that the food composition data from foreign food do not represent the food composition of local food		x
Assurance that fortification is taken into account	x	
Assurance that components have the same definition, mode of expression and units	x	
Assurance that correction factors are applied to relevant nutrient values when there are significant differences in water, protein and/or fat values between the food in one's own database and the food(s) from which values are copied	x	
Assurance that values are copied from other sources only in the event there is no significant difference in water, protein and/or fat values between one's own food and the foods from which values are copied		x
Assurance that the analytical methods of the foreign source generate similar values for the food as required for one's own database in order to obtain high-quality scores	x	

For your information:
Preparation steps, as they appear in recipe books, are often too detailed to be all described in the food composition table. Only essential steps should be reported such as cooking methods and times or water loss.

XI.Q8 Determine the correct order of usefulness of different data quality identifications for users: 1 being the most useful and 4 the least useful. *(2 points: ½ point for each correct response)*

Answer:

	Usefulness of data quality identifications for users
1	Each component value in the user database is accompanied by a confidence code: A, B or C - with explanations, e.g. A = good confidence in value; B = some confidence but with limitations, C = low confidence but best estimate. If required, further information may be obtained from the compiler.
3	Confidence codes A, B, C are provided at the food level with explanations, e.g. A = confidence in values; B = some confidence but with limitations, C = low confidence but best estimates. If required, further information may be obtained from the compiler.
4	No quality codes are given.
2	Each component value is accompanied by a confidence code: A, B, C with explanations, e.g. A = confidence in value; B = some confidence but with limitations, C = low confidence but best estimate. No additional information may be obtained from the compiler.

For your information:
Confidence codes at the value level are always more useful than at the food level, but both are preferable to no quality indication whatsoever. It should always be possible to obtain further information from the compiler if so required.

XI.Q9 The principles of Hazard Analysis Critical Control Points (HACCP), as used in food safety, may be also applied to quality assurance when compiling food composition data. The purpose is to identify potential risks and the critical control points (CCP) where preventive or corrective measures can be applied. Standard operating procedures (SOP) describe the tasks to be undertaken to prevent, decrease or eliminate the occurrence of risk. EuroFIR has used the HACCP approach in describing the compilation process and have identified CCPs and described SOPs for critical points in the data compilation (Westenbrink *et al.*, 2008). Match the following tasks to the line of the corresponding possible risk, consequence and preventive/corrective measures in the database. *(9 points: ½ point for each correct response)*

Note: The tasks, possible risks, consequences and preventive/corrective measures are adapted from Westenbrink *et al.,* (2008).

FCDB: food composition database.
FCDBMS: food composition database management system.

Tasks:
1. Selection of foods and components
2. Identification of relevant foods, components, values and meta data in other sources for incorporation into one's own database
3. Attribution of quality index to all original data to be incorporated into the database by taking account of food and component identification, sampling and analysis
4. Incorporation of original data and their storage in the archival database (e.g. manual data entry or import of data sets)
5. Selection of data to produce aggregated or calculated values
6. Selection of algorithms and factors, such as yield and retention factors, to calculate values (e.g. means, recipes, derived nutrients)
7. Calculation of nutrient values through recipe calculations
8. Validation of aggregated, calculated and otherwise compiled data, and correction of identified errors
9. Selection of data for the user database and dissemination of the latter.

Answer:

Task	Possible risks for FCDB	Consequences for FCDB	Preventive/corrective measures
7	Incorrect application of one or more steps in the recipe calculation	Errors in published values which are calculated	- Use a well-designed FCDBMS with good recipe calculation program - Train compiler - Document data - Check and validate all calculated data
4	- Data entry incomplete or inaccurate - Incomplete data documentation	- Insufficient or erroneous data entered into archival database - Loss of traceability - Error in published data	- A well-designed FCDBMS generates automatic error messages - Check that data have been copied/imported both correctly and completely - Check documentation
1	Incorrect selection of food and components for FCDB	Important foods and/or components are not included in the FCDB and are therefore not available to users	Involve users to assure user satisfaction and coverage of their needs
9	Inadequate data selected and published	Complaints are received from dissatisfied users and data suppliers	- Define criteria - Develop standardized extraction system - Involve users to assure user satisfaction and coverage of their needs
2	- Inappropriate search for relevant data - Incomplete or insufficiently described data sets - Criteria for data inclusion insufficiently described	- Inappropriate data unintentionally included in FCDB - Errors in published data through wrong selection of data	- Develop criteria or preferably use internationally-recognized criteria for data search and selection - Solicit additional information from data owner, if required - Document data
8	- No validation - Non-systematic or inaccurate validation - No special attention paid to high-risk data	Errors in published data through non-detection of errors	- Develop validation system or preferably use internationally recognized validation system with defined criteria and procedures - Document data
5	Incorrect selection of nutrient values to be included in calculations and aggregations	- Errors in published values which are calculated - Data are not representative	- Develop criteria or preferably use internationally recognized criteria for data selection - Document data
3	No or poorly defined data quality assessment system that allows for different interpretations	Data assessment neither repeatable nor comparable	- Develop a data assessment system or preferably use an internationally recognized system - Train compiler on data assessment - Document data
6	Errors in calculation algorithms, or in selection of yield and/or retention factors	- Errors in published values which are calculated - Data are not representative	- Develop a calculation system and factors, or preferably use an internationally recognized system and factors - Document data

For your information:
The incorrect application of those tasks usually leads to errors in data or to an inaccurate selection of foods and/or components. This may result in major problems for users because they do not find data for the foods or components of interest, meaning that they may have to compile these missing data themselves. The risk of error in doing so depends on the level of users' knowledge of food composition. Errors in published food composition data, however, always lead to errors in their application (e.g. nutrient intake estimations, nutritional adequacy, therapeutic and other diets, labelling, or policy decisions and nutritional programmes). In the latter case, users may not be aware that they are using erroneous data.

The article by Westenbrink *et al.*, 2008, includes a useful and informative flow chart.

SAMPLE ANSWERS TO THE EXERCISES

XI.E1 Indicate which quality index (QI) would be attributed by the data quality assessment systems of AFSSA (France), USDA and EuroFIR for the situations listed in the table below. *(24.5 points: ½ point for each correct response)*

Note:

- The AFSSA (France) data quality assessment system may be found at p. 29 of the EuroFIR (2007) document
- The USDA data quality assessment system may be found in Holden, Bhagwat and Patterson (2002). Development of a multinutrient data quality evaluation system. *J. Food Compos. Anal.*, 15(4): 339–348. Available at http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%236879%232002%23999849995%23341462%23FLP%23&_cdi=6879&_pubType=J&_auth=y&_acct=C000055286&_version=1&_urlVersion=0&_userid=6718006&md5=c50ea9203aa7a0b2dce40ca403eaf868.
An example is given on pp. 27-28 of the EuroFIR (2007) document. For students unable to download the article, the exercise may be completed with information provided in Greenfield & Southgate (2003) in box 10.1 (p. 185).
- The EuroFIR data quality assessment system may be found in EuroFIR (2007): EuroFIR Workpackage 1.3, Task group 4. Guidelines for quality index attribution to original data from scientific literature or reports for EuroFIR data interchange. Draft document. Available at HTTP://WWW.EUROFIR.ORG/EUROFIR/DOWNLOADS/VALUEDOCUMENTATION/QI_GUIDELINES_DRAFT_TESTVERSION300707.DOC

Answer (see Greenfield and Southgate, 2003 pp. 184-185; EuroFIR, 2007; Holden, Bhagwat and Patterson, 2002):

Situation	AFSSA, France, (max. QI 100 points)	USDA (max. QI 100 points)	EuroFIR (max. QI 35 points)
Example: Nutrient values are provided with good food and component identification; all other evaluation categories obtain highest scores.	**100 (20+20+20+10 +10+10+10)**	**100 (20+20+20 +20+20)**	**35 (5+5+5+5 +5+5+5)**
Nutrient values are provided only with good food and component description, and with unit and denominator but without additional information.	20 (20+0+0+0 +0+0+0)	0	15 (5+5+1+1 +1+1+1)
Nutrient values are provided with ambiguous food identification (e.g. meat); all other evaluation categories obtain highest scores.	reject data	100 (20+20+20 +20+20)	31 (1+5+5+5+ 5+5+5)
Nutrient values are provided with ambiguous component identification and method (e.g. vitamin E, carbohydrates); all other evaluation categories obtain highest scores.	reject data	**Intermediate information on analytical method = 10 points** 90 (20+20+20 +20+10)	31 (5+3+5+5 +5+3+5)
No information is provided on unit or denominator; all other evaluation categories obtain highest scores.	100 (20+20+20 +10+10+10+10)	100 (20+20+20 +20+20)	33 (5+3+5+5 +5+5+5)
Sampling plan is perfect for another country but not representative of one's own country; all other evaluation categories obtain highest scores.	100 (20+20+20+10 +10+10+10)	100 (20+20+20 +20+20)	34 (5+5+5+4 +5+5+5)
Three independent samples are analysed (minimum for publishing compositional data in most scientific literature); all other evaluation categories obtain highest scores.	86 (20+20+6+ 10+10+10+10)	**n=3 gives 6 points** 86 (20+6+20 +20+20)	33 (5+5+5+3 +5+5+5)

continued table

For a vitamin C value, no information is provided on sample handling in the laboratory or during transportation; all other evaluation categories obtain highest scores.	98 (20+20+20+ 8+10+10+10)	**If proper storage is essential but not described minus 4 points** 96 (20+20+16 +20+20)	31 (5+5+5+5 +1+5+5)
No information is provided on quality assurance; all other evaluation categories obtain highest scores.	90 (20+20+20+10 +10+0+10)	80 (20+20+20 +20+0)	31 (5+5+5+5 +5+5+1)
Analytical method is described well, but component is obsolete (e.g. crude fibre); all other evaluation categories obtain highest scores.	100 (20+20+20+10 +10+10+10)	100 (20+20+20 +20+20)	31 (5+5+5+5 +5+1+5)
Analytical quality control/assurance is absent; all other evaluation categories obtain highest scores.	90 (20+20+20+10 +10+10+0)	80 (20+20+20 +20+0)	31 (5+5+5+5 +5+5+1)
Calculated data for well-described food within the database (e.g. energy in kJ/100 g edible food).	Not applicable	Not applicable	Not applicable
Information on an analysed recipe is good (name, description, qualitative and quantitative information on ingredients); all other evaluation categories obtain highest scores.	100 (20+20+20+10 +10+10+10)	100 (20+20+20 +20+20)	35 (5+5+5+5 +5+5+5)
Information on an analysed recipe is good (name, description, qualitative and quantitative information of ingredients); ingredients are sampled from the local shop; all other evaluation categories obtain highest scores.	81 (20+1+20+10 +10+10+10)	80 (0+20+20 +20+20)	31 (5+5+1+5 +5+5+5)
The name of an analysed recipe is given; no qualitative or quantitative information on ingredients is available; all other evaluation categories obtain highest scores.	Reject	100 (20+20+20 +20+20)	33 (3+5+5+5 +5+5+5)
The recipe is calculated. Recipe name and description is given; good qualitative and quantitative information is provided on ingredients, adequate yield and nutrient retention factors. Components, unit and denominator are described well.	Not applicable	Not applicable	Not applicable

For your information:
As the EuroFIR system leaves room for interpretation, users may attribute different points as indicated here. Full marks are obtained if the difference in points is only 1 or 2 and within the same evaluation category. EuroFIR system is the only system that gives a lower quality if sampling is done for another country. However, if the food does not represent the food as consumed in the country, the values may be very different and in this case the values should have a low overall quality.

The three data quality assessment systems are not applicable to calculated values. Therefore, calculated values do not obtain any score and the correct answer is 'not applicable'.

In the USDA system, confidence code A (considerable confidence) is attributed for a quality index of 75-100; B (confidence in this value; however some problems exist regarding the data) for a quality index of 50-74 points; C (less confidence in this value due to limited amounts and/or quality of data) for a quality index of 25-49 points; and D (significant problems) for a quality index of less than 25 points.

In principle, data should be rejected if it is not clear to which food and component the values belong, or if the unit and denominator are not clear. If the data are ambiguous, their values are of little or no use for food composition purposes.

Interpretation:
Select True or False.

Answer:

True	False	Interpretation
	x	The EuroFIR and USDA systems work well when only one of the categories is not adequately described.
x		The French system is the only one that allows for data to be rejected in the event an essential description is missing.
	x	The USDA system is the only one that attributes quality indexes accurately for sampling.
	x	All systems are well equipped to differentiate between different calculation methods in terms of the quality of calculated data.

For your information:
In general, USDA does not use data that do not identify the food, component, unit or denominator correctly (personal communication).

Data quality assessment procedures can also be used by data generators when preparing papers for submission to journals. This could ensure that their data are well documented and therefore could be well rated by the journal and reviewers.

GENERAL FEEDBACK USING SELF-SCORING

72 – 92.5 points: You have fully understood and integrated the principles of quality considerations in data compilation. Congratulations. You are well prepared to apply the new knowledge.

48 – 71 points: You have understood and integrated most of the principles of quality considerations in data compilation. This is very encouraging. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so before being able to apply the new knowledge.

24 – 47 points: You have understood and integrated a fair part of the principles of quality considerations in data compilation. You could strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so before being able to apply the new knowledge.

***0 – 23 points*:** It seems you have gaps in your understanding of the principles of quality considerations in data compilation. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so before being able to apply the new knowledge.

Module 12

FOOD BIODIVERSITY

LEARNING OBJECTIVES

By the end of this module the student will be able to:

- understand the concept of food biodiversity and its links to food and nutrition and health;
- understand the importance of food biodiversity for food composition databases and dietary assessment;
- generate, manage and use food composition data for food biodiversity purposes.

REQUIRED READING

- **Charrondiere, U.R.** PowerPoint presentation on 'Food Biodiversity and Food Composition', available at: http://www.fao.org/infoods/presentations_en.stm

and if possible:

- **FAO.** 2008. *Expert Consultation on Nutrition Indicators for Biodiversity – 1. Food Composition.* FAO, Rome. Available at: ftp://ftp.fao.org/docrep/fao/010/a1582e/a1582e00.pdf
- **FAO.** 2005. *Support for countries to generate, compile and disseminate cultivar-specific nutrient composition data, and the relative priority of obtaining cultivar-specific dietary consumption data. Commission on Genetic Resources for Food and Agriculture - Working Group on Plant Genetic Resources for Food and Agriculture.* CGFRA/WG-PGR-3/05/5. Available at: http://www.fao.org/waicent/FaoInfo/Agricult/AGP/AGPS/pgr/ITWG3rd/pdf/p3w5E.pdf
- **Toledo, A. & Burlingame, B.** 2006. Biodiversity and nutrition: a common Path Toward Global Food Security and Sustainable Development. *Journal of Food Composition and Analysis* 19(6-7): 477-483. Available at: http://www.sciencedirect.com/science/issue/6879-2006-999809993-625152
- **FAO.** 2008a. *Climate change and biodiversity for food and agriculture.* Technical background document from expert consultation, February 2008. FAO, Rome. pp. 1-8. Available at: ftp://ftp.fao.org/docrep/fao/meeting/013/ai784e.pdf

LITERATURE QUOTED IN QUESTIONS AND EXERCISES

- **Ceballos, H., Sanchez, T., Chávez, A.L., Iglesias, C. & Debouck, D.** 2006. Variation in crude protein content in cassava (Manihot esculenta Crantz) roots. *Journal of Food Composition and Analysis* 19(6-7): 589-593. Available at: http://www.sciencedirect.com/science/issue/6879-2006-999809993-625152
- **Commission of the European Communities.** 1997. Commission recommendation of 29 July 1997 concerning the scientific aspects and presentation of information necessary to support applications for the placing on the market of novel foods and novel food ingredients and the preparation of initial assessment reports under regulation (EC) No 258/97 of the European Parliament and of the Council; *Official Journal of the European Communities L253/1-36.* Available at: http://ec.europa.eu/food/food/biotechnology/novelfood/initiatives_en.htm
- **CBD**. 2006. *COP 8 Decision VIII/23 on Cross-cutting initiative on biodiversity for food and nutrition.* Accessed in 2010 at: http://www.cbd.int/decision/cop/?id=11037
- **Englberger, L., Schierle, J., Aalbersberg, W., Hofmann, P., Humphries, J., Huang, A., Lorens, A., Levendusky, A., Daniells, J., Marks, G.C. &. Fritzgerald M.H.** 2006. Carotenoid and vitamin content of Karat and other Micronesian banana cultivars. *International Journal of Food Sciences and Nutrition.* Aug-Sep; 57(5-6): 399-418
- **FAO/WHO.** 2001. *Safety assessment of foods derived from genetically modified microorganisms.* Report of a Joint FAO/WHO Expert Consultation on Foods Derived from Biotechnology held in September 2001, Geneva, Switzerland. WHO and FAO, Geneva and Rome. Available at: http://www.who.int/foodsafety/publications/biotech/en/ec_sept2001.pdf
- **Kennedy, G., Islam, O., Eyzaguirre, P. & Kennedy, S.** 2005. Field testing of plant genetic diversity indicators for nutrition surveys: rice-based diet of rural Bangladesh as a model. *Journal of Food Composition and Analysis* 18(4): 255-268
- **Talpur, F.N., Bhanger, M.I., & Khunawar, M.Y.** 2006. Comparison of fatty acids and cholesterol content in the milk of Pakistani cow breeds. *Journal of Food Composition and Analysis* 19(6-7): 698-703. Available at: http://www.sciencedirect.com/science/issue/6879-2006-999809993-625152

Module 12 – Answers

RESOURCES

Compositional data

- CINE's Arctic Nutrient File. Available at: http://www.mcgill.ca/files/cine/Traditional_Food_Composition_Nutribase.pdf

Taxonomic websites

- Plants
  - http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl
  - http://mansfeld.ipk-gatersleben.de/
  - http://www.plantnames.unimelb.edu.au/Sorting/Frontpage.html
  - http://www.seedtest.org/en/home.html
  - http://plants.usda.gov/
- Fish
  - http://www.fao.org/figis/servlet/static?dom=org&xml=sidp.xml&xp_lang=en&xp_banner=fi
  - http://www.fao.org/fi/website/FISearch.do?dom=species
  - http://www.fishbase.org/home.htm
  - http://vm.cfsan.fda.gov/%7Efrf/rfe0.html
  - http://www.nativefish.asn.au/taxonomy.html
  - http://www.nativefish.asn.au/fish.html
- Plants, animals, fish
  - http://www.ncbi.nlm.nih.gov/sites/entrez?db=Taxonomy
  - http://www.cbif.gc.ca
  - http://www.sp2000.org/
  - http://www.itis.gov/index.html

Gene bank databases

  - http://www.informatik.uni-leipzig.de/~tkirsten/GenBankManagement.html
  - http://www.bioversityinternational.org/Information_Sources/Species_Databases/Species_Compendium/default.asp

RECOMMENDATION

Sampling aspects for food biodiversity are dealt with in module 5 on Sampling

RELEVANCE FOR VARIOUS USERS (ON A SCALE OF + TO +++++)

- Compilers/ professional users +++++
- Analysts +++++

ESTIMATED TIME TO COMPLETE TASKS

- Required reading: 1-3 hours
- Answering the questions: 1-3 hour
- Completing the exercises: 1-3 hour

SUGGESTED ADDITIONAL READING

- **FAO.** 2010. *Expert Consultation on Nutrition Indicators for Biodiversity – 2. Food Consumption.* FAO, Rome. Available at: http://www.fao.org/infoods/biodiversity/index_en.stm
- **Kuhnlein, H.V., Erasmus, B. & Spigelski, D. (eds.).** 2009. *Indigenous peoples' food systems: the many dimensions of culture, diversity and environment for nutrition and health.* FAO, Centre for Indigenous Peoples' Nutrition and Environment. Rome, FAO. Available at http://www.fao.org/docrep/012/i0370e/i0370e00.htm).
- INFOODS webpage on biodiversity. Available at: http://www.fao.org/infoods/biodiversity/index_en.stm

- Bioversity International web page on biodiversity and nutrition. Available at: http://www.bioversityinternational.org/Themes/Nutrition/index.asp
- **AVRDC.** 2002. *Vegetables are vital: healthy diets, productive farmers, strong economies.* Asian Vegetable Research and Development Center, Shanhua, Taiwan. 29 pp. Available at: http://www.avrdc.org/pdf/vitalveg.pdf
- **UNESCO.** 2008. Promoting the Development of Industrial Crops in Maputaland through Capacity Building. Available at: http://www.unesco.org/csi/pub/papers2/mapp17.htm

Answers to the questions

XII.Q1 Match the terms with the corresponding definition. *(5 points: ½ point for each correct response)*

Note: See FAO, 2008, *Expert Consultation on Nutrition Indicators for Biodiversity – 1. Food Composition.* Available at: ftp://ftp.fao.org/docrep/fao/010/a1582e/a1582e00.pdf

Terms:
1. Underutilized foods
2. Species
3. Food biodiversity
4. Variety
5. Breed
6. Ecosystem
7. Cultivar
8. Subspecies
9. Genus
10. Family

Answer:

Term	Definition
5	It is a specific group of animal species, within a single zoological taxon of the lowest known rank, with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups within the same species.
8	They are population(s) of organisms sharing certain characteristics that are not present in other populations of the same species; the taxonomic naming convention is to append to the species name "ssp." or "subspec." and the Latin name is in italics.
6	It is a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
2	It is a class of potentially interbreeding individuals, below the level of genus, that are reproductively isolated from other such groups having many characteristics in common. Their classifications are subject to review and change as new genomic and other scientific evidence is considered. By convention, the name is formed of two Latin words where the genus is listed first. The name is italicized with the initial letter capitalized; e.g. apple is *Malus domestica*.
9	It is the first component of an organism's binomial scientific nomenclature, classifying an organism with like organisms. The generic name is written with an initial upper-case letter; the species name is in lower case, e.g. *Canis lupus* is the grey wolf's scientific name, *Canis* (dog) and *lupus* (wolf).
3	The diversity of plants, animals and other organisms used for food, covering the genetic resources within species, between species and provided by ecosystems.
1	It is defined as species with underexploited potential for contributing to food security, health and nutrition, income generation and environmental services. However, it is not a well-defined term; it depends on geographical, social, economic and temporal aspects, and includes a wide range of wild, traditional, indigenous and local foods. Often, taxonomic identification is not complete, especially below species level.
10	It is a taxomonic rank intermediate between order and genus. Their names are formed by adding the ending -*idae* (animals) or -*aceae* (plants) to the stem of the genus name.
4	It is a naturally-occurring subdivision of a plant species, within a single botanical taxon of the lowest known rank, with distinct morphological characteristics. It is given a Latin name according to the rules of the International Code of Nomenclature. Its name is known by the first validly published name applied to it. In zoological nomenclature, the term is not generally used (except for fish) and in bacteriological nomenclature it is used interchangeably with "subspecies".
7	It is a category of plants below the level of a subspecies taxonomically and equivalent taxonomically to variety, and found only in cultivation. It is an international term denoting certain cultivated plants that are clearly distinguishable from others by stated characteristics and that retain their distinguishing characteristics when reproduced under specific conditions. It is named with an epithet, a word or words in a vernacular language (unless published prior to 1959), or a botanical (Latin) epithet which is printed in Roman characters, not italics. It takes a capital first letter and is enclosed in single quotation marks, for example, Hosta kikutii 'Green Fountain' (hosta leaves). They have generally been registered with an appropriate body in order to associate that name with a particular population and, usually, to claim rights over it.

For your information:
Varieties and cultivars are generally at the same taxonomic level. The difference between them is that the term 'cultivar' is used only for cultivated plants (easily recognized through single quotes around the cultivar name) whereas variety applies to all plants under the species or subspecies level (easily recognized by var. in front of the name). In some specific cases, such as the genus *Brassica*, the cultivar is below the variety level, e.g. *Brassica oleracea* var. *capitata* 'January King' (Cabbage, January King).

XII.Q2 The taxonomic identification of foods is important, especially for those working in biodiversity and food composition. Complete the blanks using the following words: *(2.5 points: ½ point for each correct response)*

Variety – Species – Cultivar – Breed - Family

Answer:

Animals	
Rank	**Example**
--- Family	Bovidae
└ Genus	Bos
└ *Species*	*Bos taurus* (cow)
└ *Breed*	*Bos taurus* Bruna alpina

Plants	
Rank	**Example**
--- *Family*	Rosaceae
└ **Species**	*Malus domestica × M. sylvestris (apple)*
└ *Cultivar*	*Malus domestica × M. sylvestris* 'Granny Smith'

Plants	
Rank	**Example**
--- Family	Cruciferae
└ Species	*Brassica cretica*
└ *Variety*	*Brassica cretica* var. cauliflora (DC.) Schwarz (cauliflower)

XII. Q3 Taxonomic names are not always easy to interpret as the authors' names can be mistaken as variety, cultivar or breed name. Indicate for the following names whether they are at species, variety, cultivar or breed level. *(2.5 points: ½ point for each correct response)*

Answer:

Taxonomic name	Species	Variety	Cultivar	Breed
Ipomoea batatas (L.) Lam. [sweet potato]	x			
Prunus domestica 'Cacak's Beauty' [plum]			x	
Sus scrofa domestica Danish Landrace [pig]				x
Brassica oleracea L. var. *gemmifera* DC. [brussels sprouts]		x		
Vigna umbellata (Thunb.) Ohwi and H. Ohashi [rice bean]	x			

For your information:
The same food may have several taxonomic names depending on the source. Therefore, it is useful to document the source, author and year.

XII.Q4 The cross-cutting initiative on biodiversity for food and nutrition, led by FAO in collaboration with Bioversity International, was formally established by decision VIII/23 A of the Conference of the Parties to the Convention on Biological Diversity (CBD) in March 2006. Select the correct statements on food biodiversity and nutrition by indicating True or False. *(7.5 points: ½ point for each correct response)*

Note: See document 'Support for countries to generate, compile and disseminate cultivar-specific nutrient composition data, and the relative priority of obtaining cultivar-specific dietary consumption data' of the Commission on Genetic Resources for Food and Agriculture - Working Group on Plant Genetic Resources for Food and Agriculture. CGFRA/WG-PGR-3/05/5": http://www.fao.org/waicent/FaoInfo/Agricult/AGP/AGPS/pgr/ITWG3rd/pdf/p3w5E.pdf or the CBD website http://www.cbd.int/decision/cop/?id=11037

Answer:

Statements	True	False
Differences in nutrient composition between foods may be significant. Food composition and consumption data exclusively at the food level will form the evidence base for the relationship between nutrition and food biodiversity.		x
Food biodiversity is of particular significance for indigenous communities and for poor and vulnerable communities, especially in times of food shortages.	x	
Food biodiversity data should be collected for important bioactive non-nutrients only (e.g. antioxidant phytochemicals).		x
Generic food composition data are considered sufficient for most purposes; composition data on varieties/cultivars/breeds are a luxury and are not considered useful, especially for developing countries.		x
Differences in nutrient composition may be significant between foods and among varieties/cultivars/breeds of the same food. Food composition and consumption data at the variety/cultivar/breed level will form the evidence base for the relationship between nutrition and food biodiversity.	x	
In the past, generic food composition data were considered sufficient for most purposes. However, the usefulness of composition data at the variety/cultivar/breed level is increasingly acknowledged and it is therefore recommended that they be included in food composition databases.	x	
The International Rice Commission recommended that: (1) the existing biodiversity of rice varieties and their nutritional composition should be explored before engaging in transgenic research; (2) nutrient content should be one of the criteria used in cultivar promotion; and (3) cultivar-specific nutrient analysis and data dissemination should be undertaken systematically.	x	
Food biodiversity is only important for developing countries.		x
Respondents to food consumption surveys may be capable of reporting intakes of species and selected varieties/cultivars/breeds by local names for certain foods, e.g. frequently consumed foods.	x	
Integrating food biodiversity and nutrition can contribute to achieving the Millennium Development Goals.	x	
Because developing countries and countries in transition find it difficult to devote resources to strengthening laboratory capabilities, they should not undertake nutrient analyses of individual varieties/cultivars/breeds.		x
Knowledge of composition and consumption of intra-species diversity may be useful in the development of food-based dietary guidelines and nutrition education programmes.	x	
The absence of composition and consumption data at the variety/cultivar/breed level limits our ability to assess the value of varieties/cultivars/breeds and their importance to individual, household and national food security, as well as to trade and the environment sector.	x	
Food biodiversity data should be collected and analysed for all components, including energy, proteins and amino acids, fats and fatty acids, minerals, vitamins, pro-vitamins as well as bioactive non-nutrients (e.g. antioxidant phytochemicals).	x	
Food biodiversity has no particular role to play in addressing micronutrient deficiencies or the poverty- and urbanization-related problems of undernutrition and obesity.		x

For your information:
The first statement is wrong because food biodiversity does not look exclusively at the food level but is mainly interested in varieties/cultivars/breeds.

XII.Q5 In countries where rice is the major staple food, many rice cultivars exist but no data are available on their consumption or composition. However, from the literature it may be assumed that cultivars have a wide range of nutrient values for many vitamins and for protein. How are estimates of vitamin and protein intakes and of dietary adequacy influenced when the average value of the national database for rice is applied to all cultivars compared with when compositional and consumption data are available for each cultivar and are applied to calculate the nutrient intake? Select the correct responses indicating whether the impact is due to the availability of only the average values or of the major cultivars. *(2.5 points: ½ point for each correct response)*

Answer:

Impact on nutrient intake estimations, dietary adequacy and nutrition education	When only average nutrient values of rice are available	When food composition and consumption data are available for all major rice cultivars
As rice is a staple food, the bias on nutrient intake estimations is more significant compared to foods consumed infrequently and in small quantities.	x	
Nutrient intake estimations reflect more accurately what different people consume.		x
The application of correct nutrient values for varieties/cultivars/breeds can make the difference between dietary adequacy and inadequacy for the population group.		x
Bias is introduced in dietary adequacy estimations.	x	
Nutrition education programmes can promote the cultivars with the nutrient composition which are most adequate to combat existing nutrient deficiencies.		x

XII.Q6 There is a traditional belief that one of the rice cultivars is better for people with diabetes than other rice cultivars. As no compositional data were available for this cultivar, this tradition was rarely followed and was forgotten. One researcher came to know about this belief, analysed the rice cultivar and discovered that its Glycemic Index was much lower than that of other rice cultivars. Once these results were published, the rice cultivar was recommended by the National Institute of Nutrition for patients with diabetes. Which lessons can be learned from this anecdote? Select True or False. *(2 points: ½ point for each correct response)*

Answer:

Lessons learned	True	False
Traditional beliefs without scientific background should be neglected in modern societies and not be investigated.		x
Compositional (and corresponding consumption) data are useful to verify traditional beliefs.	x	
Compositional (and corresponding consumption) data on specific foods and/or on variety/cultivar/breed levels will allow researchers to investigate the relationship between food biodiversity, nutrition and health.	x	
Compositional (and corresponding consumption) data at the variety/cultivar/breed level are not essential. Therefore they do not need to be included in national food composition databases.		x

XII.Q7 The concept of *substantial equivalence* was developed by FAO, WHO and OECD. The concept 'embodies the idea that existing organisms used as food, or as a source of food, can be used as the basis for comparison when assessing the safety of human consumption of a food or food component that has been modified or is new.' The concept of *substantial equivalence* involves a targeted analysis of the composition of the genetically-modified organisms (GMO) compared with their conventional counterparts. The major limitation of profiling is the need to document the background of normal variation and to interpret the significance of any differences detected. Several steps must be taken before the full potential of these techniques can be realized in routine safety assessments. First, the methodologies must be validated to ensure their reproducibility and robustness, and then agreement must be reached regarding assessing their performance. That is, what is the range of differences in a given food or profile that will be considered as 'normal variation'? Any profile differences considered not to be within this natural variation must be evaluated from a safety perspective. The concept of *substantial equivalence* is also applied in the European Union to novel foods, novel food ingredients and GMOs (FAO/WHO, 2001; CEU, 1997). What role could food composition databases play in this respect? Select True or False. *(2 points: ½ point for each correct response)*

Answer:

Role of food composition databases in relation to the concept of *substantial equivalence*	True	False
Better coverage of the nutritional composition of conventional foods (existing varieties/cultivars/breeds) in published food composition databases would facilitate the conducting of safety assessments of GMOs and novel foods and ingredients.	x	
Better coverage of the nutritional composition of only the most commercialized varieties/cultivars/breeds in published food composition databases would make it possible to conduct safety assessments of all GMOs and novel foods and ingredients.		x
Better coverage of the nutritional composition of existing varieties/cultivars/breeds in published food composition databases can identify varieties/cultivars/breeds with high nutritional quality covering the nutritional needs of the population. Discovery of existing biodiversity could render expensive research on new GMOs with improved composition unnecessary.	x	
Better knowledge of the nutritional composition of conventional foods would facilitate the conduct of safety assessments of corresponding GMO foods.	x	

For your information:
To be able to apply the concept of *substantial equivalence*, the analytical methods of components should be validated, robust and reproducible, and perform well. For more information on the terms used in quality assessments of analytical methods, see modules 4.d and 6.

XII.Q8 A survey in Bangladesh (Kennedy *et al.*, 2005) showed that more than 80% of households were able to identify rice by cultivar, and 38 different cultivars were named. What lessons can be learned for future food consumption surveys? Select True or False. *(2 points: ½ point for each correct response)*

Answer:

Possible lessons learned for future food consumption surveys	True	False
This was a pilot study and results cannot be transferred to other settings. Participants in food consumption surveys are not able to identify or name varieties/cultivars/breeds.		x
Current food consumption survey tools can be improved to reflect the biodiversity of selected foods, e.g. of foods highly consumed by the population.	x	
For selected foods, additional questions could be asked about the variety/cultivar/breed and local names.	x	
Food consumption data on variety/cultivar/breed level would encourage food composition compilers to generate compositional data for these foods. These consumption data, combined with a comprehensive database on food biodiversity, would allow for more precise nutrient intake estimations of the people surveyed.	x	

XII.Q9 **In the Marshall Islands, the population suffers from vitamin A deficiency. A study (Englberger *et al.*, 2006) showed that only two of the three commonly consumed varieties of Pandanus fruits are rich in carotenoids. Another study in Pakistan (Talpur *et al.*, 2006) showed that the milk of two Pakistani cow breeds had significantly different fatty acid contents under the same housing and feeding conditions: the White Thari breed produces milk with a significantly higher amount of saturated fatty acids, but lower amounts of mono-unsaturated fatty acids, polyunsaturated fatty acids and conjugated linoleic acid as compared with the Red Sindhi cows. What are the implications that these results might have for agricultural research and programmes? Select True or False.** *(2.5 points: ½ point for each correct response)*

Answer:

Possible implications for agricultural research and programmes	True	False
Agricultural research and programmes could use these results because agriculture should provide nutritionally-adequate foods for the population to combat existing dietary deficiencies.	x	
Agricultural research and programmes should ignore these results because they should take account only of agricultural parameters, such as yield or pest resistance, without considering the nutritional content or the dietary deficiencies of the population.		x
Higher nutrient value products could be commercialized and traded as foods with added value, which may achieve similar or higher prices and a wider distribution. This is most likely to happen if the yield and other agricultural factors are similar to those of the nutritionally lower-quality food.	x	
Food biodiversity will enter the market only if the producer is able to achieve a similar or higher income with the new crop compared with other crops.	x	
Release of improved varieties and breed improvement programmes should be associated with improved nutrient content, not just productivity and/or insect/pest/disease resistance.	x	

For those with advanced knowledge

XII.Q10 **Why is food biodiversity neglected? Select True or False.** *(4 points: ½ point for each correct response)*

Answer:

Possible reasons why food biodiversity is neglected	True	False
Lack of awareness of its importance for nutrition, health and agriculture.	x	
Even if compositional data at the variety/cultivar/breed level were generated they are not widely disseminated, e.g. in scientific literature, national food composition tables and databases, or reports. Therefore, farmers and consumers are not aware of the higher nutrient values of specific varieties and do not grow or consume these foods.	x	
The selection of foods to be analysed using the key food approach[38] rarely identifies foods at the variety/cultivar/breed levels. Therefore, these foods are not analysed and farmers and consumers are not aware of the higher nutrient values of specific varieties and do not grow or consume these foods.	x	
Lack of funds for chemical analysis of foods in general and for varieties/cultivars/breeds in particular for the determination of their contents.	x	
Development of GMO foods with similar nutrient composition is less expensive than investigating food biodiversity.		x
Food consumption data are not usually compiled at the variety/cultivar/breed level – also because few compositional data on them exist.	x	
National food composition databases already contain a substantial amount of compositional data at the variety/cultivar/breed levels, or data relating to different regions or seasons.		x
Lack of support from major donors (e.g. governments, international organizations) for the generation of compositional data specifically on varieties/cultivars/breeds level.	x	

[38] See module 3 for details on the key food approach.

XII.Q11 **Biodiversity is closely linked to climate change. Indicate the correct statements in this regard. Select True or False.** *(3 points: ½ point for each correct response)*

Answer (see FAO, 2008a, pp. 1-8):

Statements about biodiversity and climate change	True	False
Climate change will be one of the major drivers of biodiversity loss.	x	
Extreme climatic events will increase disturbance of agro-ecosystems, which can be buffered through the sustainable use of agricultural biodiversity. Good management of agricultural biodiversity allows production systems to adapt to changing conditions while maintaining productivity. Sustainable use of agricultural biodiversity has a huge potential for developing win-win strategies with multiple benefits, such as coping with climate change, conserving biodiversity and improving human well-being.	x	
Increased air and water temperatures will not affect the migration of species because they are bound to the existing ecosystem in the specific location.		x
Genetic diversity, which is currently underutilized, may become more attractive to farmers and policy-makers as a result of climate change. Maintaining and using a wide basket of genetic diversity at a time of climate change will be an essential insurance policy for the food and agriculture sectors and will form the basis of adaptation strategies required in food and agriculture.	x	
Climate change is likely to affect the composition of foods.	x	
National inventories on biodiversity include all relevant spatial information to assess threats caused by climate change to species, populations or genotypes of relevance to food and agriculture.		x

For your information:
National inventories on biodiversity seldom exist but they could be very useful.

SAMPLE ANSWERS TO THE EXERCISES

XII.E1 A study (Ceballos, *et al.*, 2006) on the protein content of cassava roots showed significant variations across countries and varieties. The range was 0.95 g to 6.42 g protein/100g food with a mean of 3.24 g protein/100 g food. Calculate the protein intake from cassava roots in the Democratic Republic of the Congo using the minimum, the maximum and the mean value of the protein content; compare it to the recommended daily intake (RDI) for an adult; and calculate the proportion of protein covered by cassava root in the three cases. Complete the table below. Then select the correct statement(s) for interpreting the results. *(8 points: 1 point for each correct calculation and ½ point for each correct response in the interpretation)*

Note:

- The RDI for proteins is 0.75 g per kilogram of body weight. This results in a RDI for protein of 45 g/d for an adult weighing 60 kg.
- In the Democratic Republic of the Congo, the food supply[39] of cassava is 286 g per capita per day (year 2000, as published in CD from FAOSTAT, 2005).

Answer:

	Protein content in g/100 g	Cassava intake in g/d/person	Protein intake through cassava in g/d/person	RDI for protein for an adult of 60 kg in g/d	Part of the RDI for protein covered by cassava intake, in %
Average protein content	**3.24**	**286**	9.26 (= 3.24 x 286/100)	**45**	20.6 (=9.26/45x100)
Minimum protein content	**0.95**	**286**	2.72 (=0.95 x 286/100)	**45**	6.0 (=2.72/45x100)
Maximum protein content	**6.42**	**286**	18.36 (=6.42 x 286/100)	**45**	40.8 (= 18.36/45 x 100)

Interpretation of results:

True	False	Interpretation of protein intake and adequacy
x		Food biodiversity may have a major impact on both macro- and micronutrient intakes and dietary adequacy.
x		The nutrient contents of foods, and therefore nutrient intake, may be significantly different when different cultivars/varieties/breeds are consumed. In addition, nutrient contents can be influenced by the environment.
	x	The impact on the protein intake is small because the protein content of cassava is low.
x		Food biodiversity should be taken more into account in food consumption studies and in food composition databases to allow for a better estimation of dietary adequacy or inadequacy.

[39] Food supply = food available for human consumption

XII.E2 Banana varieties/cultivars may have different nutrient compositions. The USDA database (Standard Release 21) indicates a β-carotene content of 26 mcg/100 g for banana (*Musa X paradisiaca*); the Philippine food composition table indicates 360 mcg/100 g for the banana variety Lacatan; and in Micronesia, Englberger *et al.* (2006) found 8508 mcg/100 g for the banana variety Utin Iap. Calculate for the Philippine population the β-carotene intakes from banana using the β-carotene values from USDA, Lacatan and Utin Iap; compare them to the RDI for an adult male; and calculate the proportion of the RDI for an adult male for β-carotene covered by banana in the three cases. Complete the table below. Then select the correct statement(s) for interpretation of the results. *(11.5 points: 1 point for each correct calculation and ½ point for each correct response in the interpretation)*

Information:

- The consumption of bananas in the Philippines in 2003 was 93 g/day per capita.
- The RDI for vitamin A is 600 mcg retinol equivalents (RE) for an adult male.
- 6 mcg of β-carotene provide the vitamin activity of 1 RE[40].

Answer:

Banana	β-carotene content in mcg/100 g	Banana intake in g/d/p	β-carotene intake through banana in mcg/d/p	Vitamin A intake through banana in mcg RE/d/p	Part of the RDI for vitamin A covered by banana intake, in %
USDA	**26**	**93**	24.2 (=93 x 26/100)	4 (=24/6)	0.7 (=4/600 x 100)
Lacatan	**360**	**93**	334.8 (=93 x 360/100)	56 (=335/6)	9.3 (=56/600 x 100)
Utin Iap	**8508**	**93**	7912.4 (=93 x 8508 /100)	1318.7 (=7912/6)	219.8 (=1319/600 x 100)

Interpretation of results:

True	False	Interpretation of β-carotene intake from banana and dietary adequacy
	x	Macronutrient contents (e.g. protein content in cassava) vary more than micronutrients among different cultivars/varieties/breeds.
x		Food biodiversity may determine dietary adequacy or inadequacy, especially for micronutrients
x		Copying the micronutrient contents from other sources to the national food composition table, especially without verifying the cultivar/variety of the plant, may introduce errors in nutrient values and consequently in the estimation of nutrient intake and dietary adequacy.
x		Wrong decisions might have been taken in nutrition and health programmes because of inadequate micronutrient values in the food composition table that did not reflect the composition of the varieties consumed by the population.
x		Food biodiversity should be taken more into account in food consumption studies and in food composition databases to allow for a better estimation of nutrient intakes and dietary adequacy/inadequacy.

For your information:
Many fruits increase their carotene content as they ripen. The presence of carotenes is characterized by a yellow or orange colour in some foods, with the intensity of colour indicating higher carotene content. Carotenes are also found in dark green vegetables.

In Micronesia, a programme aimed primarily at promoting green leafy vegetables was carried out over a period of 15 years. An evaluation of the programme showed that little progress had been made as these vegetables were neither indigenous foods nor well-liked by the population. Indigenous foods such as Karat banana and yellow-fleshed giant swamp taro varieties were not promoted as no compositional data

[40] More information on expressions of vitamin A is given in modules 4.b and 4.c.

were available. Since the high provitamin A carotenoid content of the Karat variety was identified, a new programme has been launched to promote carotenoid-rich indigenous foods.

Recent research has led some countries to calculate vitamin A with as Retinol Activity Equivalents (RAE), i.e. that 12 mcg of β-carotene-equivalent corresponds to 1 RE, because conversion from carotenes into vitamin A is not as efficient as originally estimated. For more information on vitamin A expressions see modules 4.b and 4.c.

XII.E3 The Nutrition Indicator for Biodiversity concerning food composition will be used to demonstrate trends in the availability of compositional data on food biodiversity in the published and unpublished literature. In a given country, the main foods consumed are rice, potatoes, legumes, tomatoes, onions, mango, beef, buffalo and fish. Some groups gather and consume insects, aquatic animals, fruits and vegetables. Select the foods that would count for the Nutrition Indicator for Biodiversity concerning food composition by using the criteria of the Expert Consultation report (see ftp://ftp.fao.org/docrep/fao/010/a1582e/a1582e00.pdf). Write Yes or No. *(9 points: ½ point for each correct response)*

Note: A more detailed list of criteria was developed and should be used when deciding which foods count for the Nutrition Indicator for Biodiversity. It is found at: http://www.fao.org/infoods/biodiversity/foods%20counting%20for%20Nutritional%20indicator.pdf

Answer:

Counts for Nutrition Indicator for Biodiversity Yes/No	Food names	Scientific names
No (common food and no indication of variety/cultivar)	Rice, white, polished, raw	*Oryza sativa*
No (variety name is for the brassica family which is an taxonomic exception and therefore does not count)	Kohlrabi	*Brassica oleracea* var. gongylodes L.
No (common food and no indication of variety/cultivar)	Tomato, raw	*Lycopersicon esculentum*
No (food description is not sufficiently specific)	Wild dark green leaves	-
Yes (variety name is provided)	Banana, pink banana	*Musa sapientum* Teod var. violacea
Yes (cultivar name is provided)	Banana, silver bluggoe	Musa sp., 'Hug-mook'
Yes (cultivar name is provided; it would also be correct to choose mango, pimsen-mun, ripe, but only one of the two counts)	Mango, pimsen-mun, unripe	*Mangifera indica*, 'pimsen-mun'
No (see above)	Mango, pimsen-mun, ripe	*Mangifera indica*, 'pimsen-mun'
Yes (wild)	Saba, fruit, gathered, raw	-
No (common food and no indication of breed)	Buffalo, lean (loin), raw	*Bubalua buffelus*
No (common food and no indication of breed)	Carabeef, lean, raw	*Bubalus bubalis*
Yes (wild)	Canada goose, raw (wild)	*Branta Canadensis*
No (raw Canada goose is counted)	Canada goose, roasted (wild)	*Branta Canadensis*
No (common food and no indication of variety/cultivar)	Carp fish, common, raw	*Cyprinus carpio* Linn.
Yes (underutilized food)	Water spinach	*Ipomea aquatica*
Yes (wild)	Red ant (gathered)	*Solenopis Invicta*
Yes (wild)	Bamboo caterpillar worm (gathered)	-
No (processed food)	Yoghurt, traditional	-

For your information:
When several forms of the same food exist (e.g. raw and roasted or ripe and unripe), the food counts only once.

GENERAL FEEDBACK USING SELF-SCORING

46 – 64 points: You have understood and integrated the issues concerning food biodiversity in relation to food composition and nutrition. Congratulations. You are well prepared to apply the new knowledge.

31 – 45 points: You have understood and integrated most issues concerning food biodiversity in relation to food composition and nutrition. This is very encouraging. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is recommended that you do so before being able to apply the new knowledge.

16 – 30 points: You have understood and integrated a fair part of issues concerning food biodiversity in relation to food composition and nutrition. You should strengthen your knowledge by returning to the sections where you did not obtain all possible points. It is highly recommended that you do so before being able to apply the new knowledge.

0 – 15 points: It seems there are significant gaps in your understanding of issues concerning food biodiversity in relation to food composition and nutrition. You should read the sections again and improve your knowledge of these topics before being able to apply the new knowledge.