



## Report

## Report on the FAO/INFOODS Compilation Tool: A simple system to manage food composition data

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## ABSTRACT

The need for a food composition database management system (FCDBMS) has been recognized since the early days 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 publicly 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.

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## 1. Introduction

Early food composition data existed only on paper and their documentation, if available, was as stored as paper archives which were not always readily accessible to successive compilers. When computers became more common, about 20–30 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. 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). However, it was agreed that a single international database would not be desirable but that an easy and accurate interchange system should be developed (Klensin, 1992).

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 the European Food Information Resource Network (EuroFIR) (Møller et al., 2008a), food nomenclature (Languel, 2010); guidelines on interchange and database management and transport package by NORFOODS (Møller, 1992); CEEFOODS (ALIMENTA, 2010), EUROFOODS (Schlotke et al., 2000), INFOODS/FAO (FAO, 2004a), or EuroFIR (Møller et al., 2008b,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 and Unwin, 1995), CERES (FAO, 2004b) or the German platform

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(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., 2008b,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. Materials 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, CEEC-FOODS and ASEANFOODS), EuroFIR, Codex Alimentarius, IUPAC, AgMES metadata elements (FAO, 2010) and ISO. The investigation assisted in deciding which standards and formats were 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, 2010a).

The Compilation Tool has been used in different settings in conjunction with the Food Composition Study Guide (Charrondiere et al., 2011), 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 factor.

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.

The Compilation Tool was developed as a simple tool that serves an immediate purpose until a more sophisticated and comprehensive food composition database management system becomes globally available.

### 3.2. Choice of standards and format

The investigation showed that there are existing relevant technical standards which either can 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 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 is a multi-platform relational database management system, are being considered for future development.

The component identifiers available from INFOODS (Klensin et al., 1989; INFOODS, 2010b) 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, 2010c) 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 disparate components due to method or data expression (e.g. as dietary fibre, carbohydrates, or folate), which result in different nutrient values needing 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.

**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

The food nomenclature is neither based on the original INFOODS (Truswell et al., 1991) nor 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, and other descriptors.

It was decided to structure the Compilation Tool according to Greenfield and 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, 2004a; Møller et al., 2008b,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, 2004a) 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., 2009c).

From the existing sets of nutrient retention factors (Bergström, 1994; McCance and Widdowson's, 2002; USDA, 2003; Bognár, 2002; Vásquez-Caicedo et al., 2007), it was decided to incorporate those of McCance and 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, 2010a): 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 and 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 and 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 formula with specific conversion factors, to calculate all values in the same manner; and 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)', where DB stands for database. 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  $100 \pm 3$  (Greenfield and 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 are 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 is to be published in the user database or table. In case the gram amount of an ingredient is not known, edible amounts in grams can be calculated in a standardized manner based on the pre-entered formulas if the necessary information is known, e.g. weight of unit or household measure and edible portion 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 (i.e. by not adding any zeros if the original value has fewer decimal places than those intended for the database, e.g. the original value of 2.2 remains 2.2 while 2.223 will be rounded to 2.22 if maximum number of decimal places is two). The 'Bibliography' worksheet contains bibliographic references used in the database. The different field names are derived from the INFOODS Standards for food composition data inter-

change (FAO, 2004a) 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 (2004a). 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, 2004a). 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).

### 3.4. 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., in press) 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, 2010d) 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 FAO, ECOWAS/WAHO and Bioersity International also used the Compilation Tool to collect and publish in a harmonized way food composition data from five West African countries (Stadlmayr et al., 2010). Charrondiere et al. (2009c) 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, e.g. integrity checks, 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). These errors can arise also because the interface is not user-friendly and it is difficult to compare or compile information which is spread over different worksheets.

## 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., 2009a,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.

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## References

- ALIMENTA, 2010. <http://www.florafood.com/> (accessed website in 2010).
- Arnouts, T., 1996. The EuroNIMS food information management system/computer demonstration. *Food Chemistry* 57 (1), 155.
- Babikyan et al., in press. Armenian Food Composition Table.
- Becker, W., Unwin, I., 1995. Food database management systems—a review. In: Greenfield, H. (Ed.), *Quality and Accessibility of Food-Related Data*. Proceedings of the First International Food Data Base Conference. AOAC International, Available at: pp. 153–165.
- 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](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/cdn\\_045/nn\\_784780/SharedDocs/Publikationen/Berichte/bfe-r-02-03,templateId=raw,property=publicationFile.pdf/bfe-r-02-03.pdf](http://www.bfel.de/cdn_045/nn_784780/SharedDocs/Publikationen/Berichte/bfe-r-02-03,templateId=raw,property=publicationFile.pdf/bfe-r-02-03.pdf).
- Burlingame, B.A., Milligan, G.C., Quigley, R.J., Spriggs, T., 1992. FOOD files Manual. New Zealand Institute for Crop and Food Research Ltd..
- CBORD, 2010. NetMenu<sup>®</sup> Planner<sup>™</sup>. <https://itcm.cbord.com/products/product.asp?id=343> (accessed in 2010 at the website).
- Charrondiere, U.R., Burlingame, B., 2007. Identifying food components: INFOODS tagnames and other component identification systems. *Journal of Food Composition and Analysis* 20, 713–716.
- Charrondiere, U.R., Burlingame, B., Berman, S., Elmadfa, I., 2009a. Food Composition Study Guide—Questions and Exercises, vol. 1. FAO, Rome. , Available at: [http://www.fao.org/infoods/publications\\_en.stm](http://www.fao.org/infoods/publications_en.stm).
- Charrondiere, U.R., Burlingame, B., Berman, S., Elmadfa, I., 2009b. Food Composition Study Guide—Answers to Questions and Exercises, vol. 2. FAO, Rome. , Available at: [http://www.fao.org/infoods/publications\\_en.stm](http://www.fao.org/infoods/publications_en.stm).
- Charrondiere, U.R., Sivieri, A., Burlingame, B., 2009c. Differences in nutrient values of recipes due to different calculation methods and sets of nutrient retention factors. Abstract S1-O-9. In: Judprasong, K., Puwastien, P., Jittinandana, S. (Eds.), *Quality Food Composition Data: Key for Health and Trade*. 8th Interna-

- tional Food Data Conference, Mahidol University, Bangkok, Thailand, 1–3 October 2009.
- Charrondiere, U.R., Freisling, H., Elmadafa, I., 2011. The distance learning tool 'Food Composition Study Guide' contributes to global capacity development in food composition. *Journal of Food Composition and Analysis* 24, 663–669.
- EuroFIR, 2010. European databases. <http://www.eurofir.org/eurofir/EuropeanDatabases.asp> (accessed in 2010).
- FAO, 2003. Food Energy—Methods of Analysis and Conversion Factor. FAO, Rome. Available at: <http://ftp.fao.org/docrep/fao/006/y5022e/y5022e00.pdf>.
- FAO, 2004a. Report of the Technical Workshop on Standards for Food Composition Data Interchange. Rome, 19–22 January 2004. Available at: <ftp://ftp.fao.org/es/esn/infoods/interchange.pdf>.
- FAO, 2004b. Uses of Food Consumption and Anthropometric Surveys in the Caribbean—How to Transform Data into Decision-Making Tools. FAO, Rome. Available at: <http://www.fao.org/docrep/008/y5825e/y5825e00.htm#Contents> or <ftp://ftp.fao.org/docrep/fao/008/y5825e/y5825e00.pdf>.
- 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, 2010. AgMES Metadata Elements. <http://www.fao.org/agris/agmes/Documents/Elements.html#top> (accessed website in 2010).
- FoodCase, 2010. [http://www.foodcase.ethz.ch/index\\_EN](http://www.foodcase.ethz.ch/index_EN) (accessed website in 2010).
- FSANZ, 2010. Food Standards Australia and New Zealand. The Nutrition Panel Calculator. <http://www.foodstandards.gov.au/foodstandards/nutritionpanel-calculator/> (webpage assessed in 2010).
- 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>.
- Hartmann, B.M., Vasquez-Caicedo, A.L., Bell, S., Krems, C., Brombach, C., 2008. The German nutrient database: basis for analysis of the nutritional status of the German population. *Journal of Food Composition and Analysis* 21, S115–S118.
- INFOODS, 1995. Report of the IUNS/UNU INFOODS Working Group on Food Data Quality Indicators. United States Department of Agriculture, June 1995. <http://www.fao.org/infoods/software/IUNS-UNU.doc>.
- INFOODS, 2004. Report of the Technical Workshop on Standards for Food Composition Data Interchange. Rome, 19–22 January 2004. <ftp://ftp.fao.org/es/esn/infoods/interchange.pdf>.
- INFOODS, 2010a. Compilation Tool Version 1.2.1 and User Guidelines. [http://www.fao.org/infoods/software\\_en.stm](http://www.fao.org/infoods/software_en.stm) (accessed in 2010).
- INFOODS, 2010b. Tagnames for Food Components. [http://www.fao.org/infoods/tagnames\\_en.stm](http://www.fao.org/infoods/tagnames_en.stm) (accessed in 2010).
- INFOODS, 2010c. Report of the INFOODS/EuroFIR Technical Meeting on Food Components held in 2009 in Bangkok. [http://www.fao.org/infoods/tagname-s\\_en.stm](http://www.fao.org/infoods/tagname-s_en.stm) (accessed in 2010).
- INFOODS, 2010d. Food Composition Database on Biodiversity. Version 1.0. [http://www.fao.org/infoods/biodiversity/index\\_en.stm](http://www.fao.org/infoods/biodiversity/index_en.stm) (accessed in 2010).
- Klensin, J.C., 1992. INFOODS Food Composition Data Interchange Handbook. United Nations University, Tokyo. 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>.
- 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> and as PDF file at <ftp://ftp.fao.org/es/esn/infoods/Klensinetal1989Identificationof-foodcomponents.pdf>.
- Langual, 2010. LanguaL Food Description System: Its Use, Thesaurus and Further Literature. <http://www.langual.org/> (accessed in 2010).
- Lephole, M.M., Khaketla, M.C., Monoto, M.E., 2006. Composition of Lesotho Foods, 1st edition. Department of Agricultural Research, Maseru.
- McCance, Widdowson's, 2002. The Composition of Foods. Food Standards Agency and Institute of Food Research, 6th Summary Edition. Royal Society of Chemistry, Cambridge.
- MySQL, 2010. <http://dev.mysql.com/downloads/> (accessed in 2010).
- Møller, A., 1992. NORFOODS computer group. Food composition data interchange among the Nordic countries: a report. In: Simonopoulos, A.P., Butrum, R.R. (Eds.), *International Food Databases and Information Exchange*, vol. 68. World Rev Nutr Diet, Karger, Basel, Switzerland, pp. 104–120.
- Møller, A., Unwin, M., Ireland, J., Roe, M., Becker, W., Colombani, P., 2008a. The EuroFIR Thesauri 2008c. Danish Food Information. EuroFIR D1.8.22. Available at: <http://www.eurofir.org/eurofir/Downloads/Thesauri/EuroFIR%20Thesauri%202008.pdf>.
- Møller, A., Christensen, T., in collaboration with Unwin, I., Roe, M., 2008b. EuroFIR XML Food Data Transport Package Specifications—Draft Report 2006-08-20. Available at: [http://www.eurofir.org/eurofir/Downloads/Food%20Transport-PackageXMLTemplate%20and%20Specifications%202006-08-20\\_MAR\\_IU\\_AM.doc](http://www.eurofir.org/eurofir/Downloads/Food%20Transport-PackageXMLTemplate%20and%20Specifications%202006-08-20_MAR_IU_AM.doc).
- Møller, A., Christensen, T., in collaboration with Unwin, I., Roe, M., Pakkala, H., Nørby, E., 2008c. 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](http://www.eurofir.org/eurofir/Downloads/XML%20Food%20Transport%20Package/EuroFIR_Food_Data_Transport_Package_1_3.pdf).
- Pennington, J.A.T., 1996. Cuisine: a descriptive factor for foods. *Terminology* 3, 155–170.
- Pennington, J.A.T., Hendricks, T.C., Douglas, J.S., Petersen, B., Kidwell, J., 1995. International interface standard for food databases. *Food Additives and Contaminants* 12, 809–820.
- Schlotke, F., Becker, W., Ireland, J., Møller, A., Ovaskainen, M.L., Monspart, J., Unwin, I. (Eds.), 2000. COST action 99—EUROFOODS Recommendations for Food Composition Database Management and Data Interchange. European Commission, COST Report EUR 19538. Available at: <ftp://ftp.fao.org/ag/agn/infoods/EurofoodsRecommendations.pdf>.
- Southgate, D.A.T., Greenfield, H., 1988. Guidelines for the production, management and use of food composition data: an INFOODS project. *Food Science and Nutrition* 42F, 15–23.
- Stadlmayr, B., Charrondiere, U.R., Addy, P., Samb, B., Enujiungha, V.N., Bayili, R.G., Fagbohoun, E.G., Smith, I.F., Thiam, I., Burlingame, B., 2010. Composition of selected foods from West Africa. FAO, Rome. ISBN 978-92-5-106652.
- Truswell, S.A., Bateson, D.J., Madafoglio, K.C., Pennington, 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>.
- U.S. Department of Agriculture, Agricultural Research Service, 2003. Table of Nutrient Retention Factors, Release 5. Available at: <http://www.nal.usda.gov/fnic/foodcomp/Data/index.html#retention>.
- USDA, 2010. USDA National Nutrient Database for Standard Reference. <http://www.ars.usda.gov/Services/docs.htm?docid=8964> (website accessed in 2010).
- Vásquez-Caicedo, A.L., Bell, S., Hartmann, B., 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). Available at: <http://www.eurofir.org/eurofir/RecipeCalculation.asp>.
- Vignat, J., Ireland, J., Møller, A., Unwin, I.D., Charrondiere, U.R., 2001. Guideline notes for preparing and exporting food composition data according to the common formats of export files. In: Proceedings of the Fourth International Food Data Conference, Bratislava, Slovakia.

# Proximate and Mineral Composition of Three Nigerian Freshwater Fishes

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**Abstract:** Three Nigerian freshwater fishes were analysed for their proximate and mineral composition. *Oreochromis niloticus*, *Clarias lazera* and *Mormyrus rume* are classified as being in the low-fat class. *Oreochromis niloticus* has the highest mineral content.

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Key words: *Mormyrus rume*, *Clarias lazera*, *Oreochromis niloticus*, freshwater.

## INTRODUCTION

Fish is an excellent source of protein. The flesh of fish contains all the 10 essential amino acids—lysine, threonine, methionine, phenylalanine, valine, arginine, histidine, leucine, isoleucine and tryptophan in desirable concentrations for human beings (Peterson 1978, Qyvind *et al* 1994). Also, fish protein is more digestible ( $\geq 95\%$ ) than other meat protein because of the absence of collagen. It is a good supplement to a high cereal diet because of its high lysine content. In addition, fish fat is one of the very few natural food sources of vitamin D and contains important amounts of vitamins A and E ( $\alpha$ -tocopherol; Bhuiyan *et al* 1993, Qyvind *et al* 1994).

Most of the literature reports on the temperate marine and freshwater fishes; thus, little information is available on the nutritional status of the Nigerian freshwater fish. Hence, the need to carry out this study, which includes the determination of the proximate and elemental composition of *Mormyrus rume*, *Clarias lazera* and *Oreochromis niloticus*. The normal habitat of the fishes is tropical swamps and rivers and they are widely distributed throughout Africa.

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## MATERIALS AND METHODS

### Materials

The fish samples were caught from River Galma, Zaria in the northern part of Nigeria between the months of January and May (dry season). The fishes were caught in the lower part of the river using small mesh nets. They were then quickly transferred to the laboratory before being killed. The fishes were eviscerated with the heads, tails, fins and scales also removed before being minced along with the bones.

### Proximate composition

Moisture content was determined by heating an accurately weighed (20 g) representative of the fish samples in a preweighed dish in an oven at 105°C until a constant weight was obtained. The lipid was extracted from the mixed fish samples with a chloroform and methanol mixture (Bligh and Dyer 1959). The nitrogen concentration of the samples was determined by the micro-Kjeldahl method of Gilchrist (1967) and multiplied by 6.25 to estimate the crude protein content, while the ash content was determined by a procedure given by Pearson (1981).

### Macro- and micro-element determination

The minerals in the fish samples were brought into solution by wet digestion using conc HNO<sub>3</sub> (63%), perchloric acid and sulphuric acid (4 : 1 : 1) (Harris 1979). Potassium and sodium were determined by Allen's method using Collins and Polkinhorne Flame Photometer (Allen 1974). Phosphorus was determined by Allen's method using Bausch-Lomb spectronic 20 (Allen 1974). Iodine was determined by Moxon and Dixon (1980) method, while the remaining elements were determined using Perkin-Elmer model 290B (US) Atomic Absorption Spectrophotometer (AOAC 1980).

## RESULTS AND DISCUSSION

### Proximate composition of the fish samples

The moisture contents for the fish samples are given in Table 1. The fish samples contained quite a high amount of water, over 700 g kg<sup>-1</sup>. These values are comparable with those of other fishes both marine and fresh water species (eg haddock, aleste, synodontis and *Tilapia zilli*), which have 730–820 g kg<sup>-1</sup> moisture (Brian and Allan 1977; Oni 1979). The values are however expectedly higher than those of beef (640 g kg<sup>-1</sup>), lamb (530 g kg<sup>-1</sup>) and pork (540 g kg<sup>-1</sup>) (Brian and Allan 1977).

The lipid in each of the fish samples was semi-solid at room temperature (25°C). *Oreochromis niloticus* with a

lipid content of 26.4 g kg<sup>-1</sup> and *Clarias lazera* (37.0 g kg<sup>-1</sup>) on a fresh weight basis and *Mormyrus rume* (41.6 g kg<sup>-1</sup>) all belong to the low-fat class (20–40 g kg<sup>-1</sup>) according to Ackman's (1989) classification.

The values of the crude protein indicate that all the fish samples are rich in protein (Table 1). The values are comparable with beef (180 g kg<sup>-1</sup>), lamb (160 g kg<sup>-1</sup>), pork (100 g kg<sup>-1</sup>), and some marine fishes (haddock, 170 g kg<sup>-1</sup>; sardine, 200 g kg<sup>-1</sup>; mackerel, 170–230 g kg<sup>-1</sup>; and oyster, 110 g kg<sup>-1</sup>) (Bhuiyan *et al* 1968; Brian and Allan 1977; Pearson 1981).

The mineral (element) contents of the fish samples analysed show that the three species are rich in calcium, phosphorus, potassium, sodium and magnesium (macro-nutrients) and of lower quantities of zinc, iron, iodine, nickel, manganese, chromium and copper (micro nutrients) (Table 2). The *Oreochromis niloticus* species had the greatest amount of the total mineral contents and *Mormyrus rume* species, the least.

## CONCLUSIONS

With fish fast becoming a main food of the world and the Nigerian diet, and with the great potential for fish oil as a health food and therapeutic substance, the need for analysing fish is becoming increasingly important. From our results, the fish samples we analysed are all rich in protein, lipid and mineral content. *Mormyrus rume* has the highest amount of protein, lipid and phosphorus. *Oreochromis niloticus* contains the highest amount of total mineral contents, while *Clarias lazera* is

**TABLE 1**  
Proximate composition (g kg<sup>-1</sup>) of the fish samples on fresh weight basis<sup>a</sup>

Samples	Moisture content	Crude lipid	Crude protein	Ash
<i>Clarias lazera</i>	744.1 ± 9.8	37.0 ± 1.4 (141.0 ± 1.8) <sup>b</sup>	188.0 ± 1.8 (685.7 ± 1.6)	12.8 ± 1.2 (64.6 ± 0.3)
<i>Mormyrus rume</i>	752.5 ± 1.3	14.6 ± 2.0 (151.7 ± 13.7)	192.2 ± 7.0 (722.2 ± 2.2)	11.7 ± 1.6 (63.5 ± 0.2)
<i>Oreochromis niloticus</i>	772.1 ± 11.5	26.4 ± 10.0 (98.1 ± 3.2)	161.5 ± 1.0 (658.3 ± 2.5)	21.5 ± 0.6 (104.4 ± 1.1)

<sup>a</sup> Three determinations were made for each sample and the standard deviation calculated.

<sup>b</sup> Values in parentheses are based on dry weight of sample.

**TABLE 2**  
Macro- and micro-elements of fish samples on fresh weight basis (mg g<sup>-1</sup>)<sup>a</sup>

Samples	Ca	P	K	Mg	Na	Zn	Fe	I	Ni	Mn	Cr	Cu
<i>Clarias lazera</i>	8.32	5.16	3.71	0.35	0.81	0.08	0.03	0.001	0.03	0.01	0.004	0.0005
<i>Mormyrus rume</i>	3.59	6.59	3.22	0.18	0.34	0.06	0.01	0.001	0.005	0.002	0.0005	0.002
<i>Oreochromis niloticus</i>	8.83	5.08	2.69	0.36	0.72	0.07	0.03	0.001	0.01	0.01	0.0005	0.003

<sup>a</sup> Duplicate determinations were made for each element.

the richest in potassium, iron, nickel, chromium and copper.

#### REFERENCES

- Ackman R G 1989 Nutritional composition of fats in seafoods. *Prog Food Nutr Sci* **13** 161–241.
- Allen S G 1974 *Chemical Analysis of Ecological Materials*. Blackwell Scientific Publications, Oxford, UK.
- AOAC 1980 *Official Methods of Analysis* (13th edn). Association of Official Analytical Chemists, Washington, DC, USA.
- Bhuiyan A K M, Ratnayake W M N, Ackman R G 1986 Stability of lipids and polyunsaturated fatty acids during smoking of Atlantic mackerel (*Scomber scombrus*). *J Am Oil Chem Soc* **63** 324–328.
- Bhuiyan A K M, Ratnayake W M N, Ackman R G 1993 Nutritional composition of raw and smoked Atlantic mackerel (*Scomber scombrus*): oil- and water-soluble vitamins. *J Food Comp Anal* **6** 172–184.
- Bligh E G, Dyer W J 1959 A rapid method of total lipid extraction and purification. *Can J Biochem Physiol* **37** 911.
- Brain A F, Allan G C 1977 *Food Science—A Chemical Approach*, (3rd edn), pp 92–341.
- Gilchrist S D W 1967 *A Practical in Agricultural Chemistry* (Vol 17). AVI Publishing Company, Westport, CT, USA.
- Harris E (1979) *Nutrition Research* (Techniques for Domestic and Wild Animals 1). Utah, USA.
- Moxon R E D, Dixon E J 1980 Semiautomatic method for the determination of total iodine in foods. *Analyst* **105** 344–352.
- Oni K S 1979 *Chemical analysis on fresh water fish*. MSc thesis, Ahmadu Bello University, Zaria, Nigeria.
- Pearson D 1981 *The Chemical Analysis of Foods*. Churchill Livingstone, Edinburgh, UK, pp 504–530.
- Peterson M S 1978 *Encyclopaedia of Food Science*. AVI Publishing Company, West Port, CT, USA.
- Qyvind L, Einar L, Amund M, Leif R N, Kjartan S 1994 Nutrient content in fish and shellfish. *Fisk Div Skr Ernaering* **6** (5) 1–101.