# 5
# Food Composition

Barbara Burlingame and U Ruth Charrondiere

*Food and Agriculture Organization of the United Nations*

**Key messages**

- Food composition work is research in its own right, and it is the fundamental underpinning to nearly all other research activities in nutrition.
- Food composition covers nutrients, bioactive non-nutrients, anti-nutrients and chemical contaminants in foods.
- Without robust food composition data, dietary surveys cannot be analysed, nutritional epidemiology cannot derive associations/causality, nutrition interventions cannot be properly targeted, nutrient requirements cannot be determined and food labels cannot be validated.
- The International Network of Food Data Systems (INFOODS), in operation since 1983 and based at FAO, provides the infrastructure for food composition data standards, harmonisation, advocacy and communication.

## 5.1 Introduction

Food composition activities include sampling and sample preparation, data generation, data compilation, data dissemination and data use.

Historically, food composition activities were limited to data on a small subset of nutrients, usually classified as proximates, vitamins, minerals, and occasionally fatty acids and amino acids. Increasingly, food composition work deals with data for any component found in food that can be measured chemically, biologically or physiologically: a greater range of conventional nutrients and different forms/activities of those nutrients, bioassay data such as measurements of protein quality or glycaemic index, bioactive non-nutrients, anti-nutrients, pesticide residues, heavy metals, additives and more. A single food composition database, with proper documentation, can accommodate data on all these types of components. However, these data are rarely combined and published in a single database.

## 5.2 Sectors

Food composition data are useful to many sectors and professions within those sectors. Health, agriculture, environment and trade (including the food industry) are the most notable sectors. The agriculture sector has had a dominant role over many decades in food composition research and service. The Food and Agriculture Organization of the United Nations (FAO) has a long history of food composition work dating back to its inception in the 1940s and it has been the United Nations (UN) agency host for the International Network of Food Data Systems (INFOODS) since 1998. The UK and USA have even longer histories in food composition work dating back to the late nineteenth century, again in the agriculture sector, with responsible agencies being the Ministry of Agriculture, Fisheries and Food and the United States Department of Agriculture (USDA) respectively.

The other historically dominant sector is health. More than half the participants in food composition conferences, and the researchers publishing food composition papers and books, are health-sector professionals. It is often the health sector that provides a high percentage of the funding for food composition work, and the sector that claims the highest percentage of data users.

Involvement of the environment sector is becoming increasingly important as it relates to the composition of food biodiversity; that is, food described at the taxonomic level below species, and wild, neglected and

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under-utilised species. The environment sector also has a leading role in determining and monitoring chemical contaminants in the food supply.

Last, trade has emerged as a sector with a great interest in food composition. Nutrient information panels on processed foods have become regulatory requirements in many countries, and analytical data on both nutrient and contaminant content are necessary documentation for global food trade. Food retailers, restaurants and other food service providers are using food composition data in response to consumer demand.

More details on the importance of food composition to different sectors are provided later in this chapter in the section on data use.

## 5.3 The Organizational Elements

### *The international level*

INFOODS was established in 1983 by the United Nations University (UNU), with an organisational framework and international management structure that include a global secretariat and regional data centres. Its mandate is the 'Promotion of international participation and cooperation in the acquisition and dissemination of complete and accurate data on the composition of foods, beverages and their ingredients, in forms appropriate to meet the needs of the various users (government agencies, nutrition scientists and educators, health and agriculture professionals, policy makers and planners, food producers/processors/retailers and consumers).' In the mid-1990s, FAO joined UNU in partnership for INFOODS. The main activities of INFOODS at the international level include the development of technical food composition standards, guidelines and tools, often through expert consultation processes; the development of technical publications and manuals; assistance to regional data centres and individual countries in developing their food composition activities; capacity development through classroom and online courses; and the biennial International Food Data Conference, which has been held in alternate years since 1993, with each second conference as an official satellite to the IUNS International Congress of Nutrition.

### *The regional level*

There are 17 regional data centres in operation, most with well-established and effective coordination. Important activities include the preparation and updating of regional food composition tables, in both electronic and printed form (e.g. in West Africa, Pacific Islands, ASEANFOODS, LATINFOODS), convening of regular food composition coordination activities and technical task forces involving all the individual countries in the region, and participating in standard-setting consultation convened by the INFOODS Secretariat.

### *The national level*

Most countries have food composition activities of one form or other. A national food composition programme is usually the result of the combination and coordination of activities, within some defined administrative framework, related to food composition data generation, compilation, dissemination and use. A steering committee is a useful structure, functioning well in many countries. This steering, or advisory, committee is ideally composed of individuals directly involved in food composition work: data generators, data compilers and data disseminators. Crucial to the effectiveness of a steering committee is the involvement of data users. The users can be selected from among dietitians, nutritionists, food industry personnel and consumer group representatives.

Often a single organisation holds the overall responsibility for managing a national food composition programme, yet it is rare that a single organisation accomplishes all the activities itself. Regardless of their affiliations, the laboratory-based data generators must interact closely with the data compilers, and the compilers must interact closely with the data users. The data compilers therefore serve the central function of, and usually serve in the role of, data disseminators (that is, they publish the data, electronically and/or as printed tables). In most countries there are other agencies with activities that have direct or indirect relationships with food composition data, but operate in concert with the national programme. In addition to the desirability of a coordinated national approach for accomplishing essential activities, it is productive and important for a national food composition programme to operate in conjunction with its regional data centre, and with ongoing international activities.

## 5.4 Technical elements

Data generation is the process whereby foods are sampled, prepared for analysis and analysed in the laboratory. Data compilation is the process whereby the data from the laboratory and other sources are examined, manipulated and incorporated into a food composition database. Data dissemination refers to the preparation and publication of books and electronic data products, which are made available to users in the various sectors.

Data use also includes the application of these data to tasks, projects and programmes in the various professional sectors.

## *Data generation*

### Sampling

Sampling – that is, the process and procedures for obtaining foods that are representative of those available and consumed – is fundamental to any food composition activity. Preparation of a sampling plan often requires the involvement of all the major contributors to a food composition programme. Data generators must be involved in sample collections, or at least the scheduling of sample collections, so that samples may be immediately and properly prepared for analysis. Data compilers must be involved because information on the sampling plan, and details such as when and where sampling took place, are important parts of a food composition database's metadata. Data users must be involved because they have the best appreciation of the foods that need to be analysed, and often of the location from which the samples should be collected. The services of a statistician are useful for developing a sampling plan, because representativeness is dictated by the number of food units collected – and analysed – to achieve the goal. The goal might be to compare compositional differences between cultivars, or to achieve year-round, nationwide mean values for a food composition database. The overall quality of food composition data is determined largely by the sampling plan.

The collected samples must be properly handled so that they arrive at the laboratory without changes that might affect their composition. The key component, crucial to the correct determination of almost all other food components and most easily affected by improper handling and storage, is water (moisture). Once samples are delivered and documented, they are prepared for analysis. Preparation may involve separation of the edible from the inedible portion (for example, removal of bones from fish, or skins and seeds from pumpkins); kitchen-type preparation (for example, boiling rice); or combining of many samples into fewer samples (for example, combining five brands of similar biscuits into one representative composite sample). After this type of preparation, samples will be stored or immediately analysed. As with sample collection and sample handling, proper documentation of all aspects of sample preparation is essential.

### Analyses

Most laboratories undertake a limited range of analyses for food composition purposes. This includes a set of core components and then additional components of interest, for example laboratory research dealing with diet-related health problems. Core nutrients usually include the complete range of proximate components (water, nitrogen for the protein calculation, fat, available carbohydrate, dietary fibre, ash, alcohol where relevant, and an energy value using factors applied to the energy-yielding proximates), some vitamins and some nutrient elements. Additional components of interest often include cholesterol, individual fatty acids and aggregations of fatty acids (for example, total saturated fatty acids), carotenoids (both provitamin A carotenoids and antioxidant carotenoids with no provitamin A activity), other bioactive non-nutrients, heavy metals and some so-called anti-nutrients (for example, phytates). Proper laboratory practices must be strictly adhered to, and laboratory quality assurance and quality control procedures, and details of analytical methodologies, must be properly documented.

Table 5.1 provides an overview of analytical methods commonly used for macronutrients, along with their applications and limitations. Table 5.2 provides an overview of commonly measured food components, their recommended units of measure for most food composition purposes, and INFOODS tagnames, the use of which will minimise misinterpretation of the food component.

## *Data compilation*

Data compilation requires a relational database management system and adherence to international food composition standards where they exist. The database should accommodate numerical data, text and graphics. Ideally, all the raw analytical data, and their attendant documentation, should be captured. The system should then be able to manipulate these data in many different ways. The same data system should provide an exhaustive reference database and any number of abridged user databases to satisfy the broad range of user requirements for food composition data. Many compilers only capture mean values, a practice that will satisfy many users. Other compilers provide more information, and therefore higher-quality databases, by including the number of samples and some expression of their variability (standard deviation [SD] or standard error [SE]). Other compilers are able to capture all the analytical data and prepare user databases with ranges (that is, high and low values), medians and many different statistical expressions of the data, satisfying a broader spectrum of users and ensuring the highest-quality database.

Some compilers publish their databases by listing calculated components – for example, a calculated value for vitamin A in retinol equivalents (RE) without individual values for retinol, provitamin A carotenoids and

**Table 5.1** Macronutrient analysis.

| Food component | Available method of analysis | Limitation | Application |
|---|---|---|---|
| Water (moisture) | Air oven* | Caramelisation 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 to 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 |
| Total nitrogen/ protein | Kjeldahl (for total nitrogen)* | Minor interference from inorganic nitrogen. Toxic wastes | Applicable to all foods |
| | Dumas (for total nitrogen)* | High cost, 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 samples | 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 |

| Food component | Available method of analysis | Limitation | Application |
|---|---|---|---|
| | 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 derivatised 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 AA and slow release of branched-chain AA | Applicable to all foods |
| | LC-MS | High cost | Applicable to all foods |
| | Colorimetry (Tryptophan and sulphur 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 standardised methods is essential | Applicable to single sugars or simple mixtures 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 mixtures |
| | HPLC* | Moderate to high cost. Choice of columns, detectors are crucial | Can be applied to complex mixtures |
| Polyols | Specific enzymatic method | Specificity of enzymes | Limited to a few polyols only |
| | HPLC* | Moderate to high cost. Lack of standardised procedures; choice of column | Can be applied to complex mixtures |
| | 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 mixtures |
| | HPLC | Moderate to high cost | Can be applied to 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 |

(*Continued*)

**Table 5.1** (*Continued*)

| Food component | Available method of analysis | Limitation | Application |
|---|---|---|---|
| **Dietary fibres** | | | |
| Total dietary fibre | AOAC method for dietary fibres (Prosky *et al.*),* an 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 |

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 |
| | ISE | |
| | Polarography | |
| Sulphur | Gravimetric | |
| | X-ray fluorescence | High cost |
| | ICP-MS | Very expensive |
| Nitrite | Colorimetry | |
| | ISE | |
| Nitrate | HPLC | High cost |

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 |
| 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 |
| | 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, GLC* | Moderate to high cost for GLC |
| | 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 | Derivitisation 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 |

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 specialised handling |

(*Continued*)

**Table 5.1** (*Continued*)
Analysis of other components

| Food component | Available method of analysis | Limitations |
|---|---|---|
| Phytic acid | Anion exchange | Inability to resolve inositol phosphates adequately |
| | HPLC | High cost |
| | GLC | Detects derivatised volatile inositol phosphate forms only after separation by ion-exchange chromatography |
| | Capillary electrophoresis | Not applicable to all foods |
| | NMR-MS | High costs. Specialised 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** and coumestrol | HPLC | Complex conjugates, and their numbers may be difficult to resolve with some reversed-phase columns and simple mobile-phase programmes (isocratic) |
| | LC-MS | Hydrolysis not required as long as masses of individual 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 |

*recommended method.
**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.
DMSO, dimethyl sulfoxide; GLC, gas-liquid chromatography; GSC, gas-solid chromatography; GLC-MS, gas-liquid chromatography coupled with mass spectrometry; 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.

**Table 5.2** Commonly measured food components, recommended units and INFOODS tagnames. For more information and additional tagnames see INFOODS (2012b), Klensin *et al.* (1989) and Charrondiere et al. (2011ab, Module 4b).

| Component | INFOODS tagnames | Unit* | Comments | European Food Information Resource (EuroFIR) component identifiers (MI = method indicator) |
|---|---|---|---|---|
| **Edible portion** | **EDIBLE:** edible portion coefficient | | • It is recommended that values for the edible part (or the inedible part/refuse) are recorded in the user table/database for each food entry (if information is available)<br>• These values are needed:<br>◦ for a good food description<br>◦ to transform the weight of foods as purchased to the edible parts of the food<br>◦ to facilitate correct food matching<br>• Different terms (e.g. edible portion, inedible portion/refuse) and modes of expression (e.g. % or coefficient) exist<br>Examples of how to calculate edible coefficients for cooked foods based on raw foods (for foods where the inedible part is not discarded, e.g. meat and fish with bones) are given in INFOODS, 2012a, p.45. | **EDIBLE** |
| **Energy** | **ENERC**: energy, total metabolisable; calculated from the energy-producing food components<br>More tagnames exist, but are generally not used in user tables/DB | kJ (kcal) | • Energy values of foods presented in the user table/DB should always be calculated in one's own DB, by applying the 'metabolisable energy' conversion factors from Atwater (1910). Different metabolisable energy conversion factors are listed in *Annex 3* (p. 36). INFOODS recommends using the 'General Atwater factors including for dietary fibre' for use in user tables/DB<br>It is not advisable to calculate kJ energy values from energy values in kcal because this may introduce bias. Energy conversion factors in kJ are neither exactly 4.184 nor 4.2 times higher than energy conversion factors in kcal; it may just give an indication | **ENERC** |
| **Water** | **WATER**: water<br>Synonyms: moisture | g | • Values for water are required at all levels of data management including archival, reference and user table/DB. Water is the most important component to check and be published in user tables/DB<br>• Water is required to calculate the nutrient values to per 100 g fresh weight of edible portion (EP) when, in the literature, nutrient values were reported on a dry matter basis (DM)<br>• DM values are not published in user tables/DB, but in the scientific literature nutrient values are often reported per 100 g DM. Values reported in DM can be recalculated to fresh weight, if the DM value or the water value of the fresh food is given. Example:<br>Calculate values from per DM to per 100 g EP: Nutrient value (NV) (g/100 g EP) = NV(g/100 g DM) × (100-water)/100 | **WATER** |

(*Continued*)

**Table 5.2** (*Continued*)

| Component | INFOODS tagnames | Unit* | Comments | European Food Information Resource (EuroFIR) component identifiers (MI = method indicator) |
|---|---|---|---|---|
| **Protein and nitrogen components** | **PROT** (formerly PROCNT): protein, total; calculated from total nitrogen<br>**XN:** conversion factor for calculating total protein from total nitrogen<br>**NNP:** non-protein nitrogen<br>**PROCNP**: protein, total; calculated from protein nitrogen<br>**NT**: nitrogen, total | g | • Values for protein are required at all levels of the data system (archival, reference and user DB)<br>• Protein is usually a calculated value derived from total nitrogen value multiplied by nitrogen conversion factors<br>• Nitrogen to protein conversion factors (XN) are given in *Annex 3* (p. 36).<br>Nitrogen, total (NT) should be part of archival, reference and comprehensive user table/DB, but must not necessarily be part of a concise/abridged user table/DB. | - **PROT** + MI<br>- Conversion factors are method parameters<br>- no correspondence for NNP<br>- **PROT** + MI<br>**NT** |
| **Total fat, fatty acids and lipid components** | **FAT**: fat, total. Sum of triglycerides, phospholipids, sterols and related compounds. The analytical method is a mixed solvent extraction.<br>Synonym: total lipid<br>**FATCE**: fat, total; derived by analysis using continuous extraction. The Soxhlet method has often been used to analyse for total fat using continuous extraction. This method tends to underestimate the total fat value of a food.<br>**FAMS**: fatty acids, total monounsaturated<br>**FAPU**: fatty acids, total polyunsaturated<br>**FASAT**: fatty acids, total saturated<br>**FATRN**: fatty acids, total *trans*<br>**FAPUN3**: fatty acids, total n-3 polyunsaturated<br>**FAPUN6**: fatty acids, total n-6 polyunsaturated | g | **Fat**<br>• Fat values are required at all levels of the database management (archival, reference and user DB)<br>• Fat values are highly method depended<br>◦ FAT is the preferred method<br>◦ FATCE: fat, total, Soxhlet, should be avoided since it leads to incomplete extraction and therefore results in lower values, in particular for foods with high amounts of polar and bound lipids<br>• Fat and water values are important to check the food description and the concordance between foods. Fat contents of foods need to be compared when estimating values for fat-soluble components (e.g. fat-soluble vitamins, fatty acids) from other sources. If the difference in fat values between the food in the own DB and in the referenced source is higher than 10% the values for fat soluble components need to be adjusted<br>**Fatty acids**<br>• Individual fatty acids should be included in the reference DB. In concise user tables/DB the fatty acids may be grouped in total saturated, total monounsaturated and total polyunsaturated fatty acids<br>Fatty acid should be expressed in mg/100 g fresh weight of the edible portion (EP). In the literature fatty acids are often expressed differently, including per g or 100 g fatty acids or fat. See the FAO/INFOODS Guidelines on Conversion among different units, denominators and expressions (FAO/INFOODS, 2012a) for further information | **FAT** + MI<br><br><br><br><br>**FAT** + MI<br><br><br><br><br><br><br>**FAMS**<br>**FAPU**<br>**FASAT**<br>**FATRS**<br>**FAPUN3**<br>**FAPUN6** |

| | | | | |
|---|---|---|---|---|
| **Carbohydrates** | **CHOAVL**: carbohydrates, available. This value includes the free sugars plus dextrins, starch, and glycogen<br>**CHOAVLM**: carbohydrates, available; expressed in monosaccharide equivalents. This value includes the free sugars plus dextrin, starch and glycogen<br>**CHOAVLDF**: carbohydrates, available; calculated by difference. This value is calculated:<br>100 – (weight in grams [water + protein + fat + ash + alcohol + dietary fibre] in 100 g of food)<br>**CHOCDF**: carbohydrates, total; calculated by difference. This value is calculated:<br>100 – (weight in grams [water + protein + fat + ash + alcohol] in 100 g of food)<br>**CHOCSM**: carbohydrates, total; calculated by summation. This value is the sum of the sugars, starches, oligosaccharide and dietary fibre | g | **Carbohydrates**<br>• Values for carbohydrates are required throughout the entire database system (archival, reference and user DB)<br>• The main difference in carbohydrates relates to:<br>o whether or not fibre is included<br>o if it is analysed or calculated by difference<br>o if the value is expressed in anhydrous form or monosaccharide equivalents<br>• Generally, available carbohydrates are always preferred to total carbohydrates, because available carbohydrates represent only the carbohydrates available to the human body<br>• The most recommended expression is available carbohydrates by summation (CHOAVL). However, this method demands analytical values; in case analytical data are not available for most foods, it is recommended to use 'carbohydrates, available by difference' (CHOAVLDF; FAO, 2003)<br>**Starch**<br>• Starches including glycogen and polysaccharides should be part of a comprehensive user DB<br>**Oligosaccharides**<br>• Are defined as carbohydrates with 3 to 9 monomeric units<br>• Some oligosaccharides can be included in dietary fibre, if they are resistant to digestion in the intestine<br>• In many foods oligosaccharides are in small amounts and are, therefore, not included in user tables/DB<br>**Sugars total**<br>• In many user tables/DB sugars are defined as mono- and disaccharides<br>Sugars should be part of a concise user table/DB and individual mono-, di- and oligosaccharides as well as polyols should be part of a comprehensive user table/DB | **CHO** + MI<br><br>**CHO** + MI + unit<br><br>**CHO** + MI<br><br>**CHOT** + MI<br><br>**CHOT** + MI |

(*Continued*)

**Table 5.2** (*Continued*)

| Component | INFOODS tagnames | Unit* | Comments | European Food Information Resource (EuroFIR) component identifiers (MI = method indicator) |
|---|---|---|---|---|
| **Fibre** | **FIBTG**: fibre, total dietary; determined gravimetrically by the AOAC total dietary fibre method (Prosky method). Sum of the water-soluble components and the water-insoluble components of dietary fibre<br>**FIBTS**: fibre, total dietary; sum of non-starch polysaccharide components and lignin (Southgate method)<br>**PSACNS/NSP**: non-starch polysaccharide, (Englyst fibre). This includes non-starch polysaccharides but excludes lignin, resistant starch and resistant oligosaccharides<br>**FIBAD**: fibre; determined by acid detergent method. Includes cellulose, lignin and some hemicellulose<br>**FIBADC**: fibre, acid detergent method, Clancy modification<br>**FIBINS**: fibre, water insoluble. Sum of insoluble components from the AOAC total dietary fibre method; includes primarily lignin, cellulose, and most of the hemicelluloses<br>**FIBSOL**: fibre, water soluble<br>**FIBND**: fibre; determined by neutral detergent method. Includes lignin, cellulose, and insoluble hemicellulose<br>**FIBC**: fibre, crude | g | • Dietary fibre values are required at all levels of the database system (archival, reference and user DB)<br>• The values for fibre are method dependent and therefore need to be identified by the method used. Any calculation including fibre (e.g. sum of proximates, or carbohydrates calculated by difference) will be affected by how the fibre content was determined<br>• New methods for dietary fibre have been developed that include all residual starch and resistant oligosaccharides. As these methods are still under development, it is suggested that one waits for finalisation before including those values in the Food Composition Database (FCDB). As Codex definition for dietary fibre may include resistant oligosaccharides, they may have to be included in FCDB in future<br>• INFOODS recommends using total dietary fibre by AOAC Prosky (Greenfield *et al*., 2002)<br>• Dietary fibre by Prosky (FIBTG) captures most completely the components with dietary fibre functions, followed by FIBTS and PSACNS/NSP<br>It would be best to phase out the use of FIBAD, FIBADC, FIBND and FIBC in favour of one of the other methods for determining total dietary fibre, such as FIBTG.<br>New fibre methods are being developed including non-digestible oligosaccharides for which new tagnames will be needed, once fully approved and used in FCTs | **FIBT** + MI<br>**FIBT** + MI<br>**NSP** + MI<br>**FIBT** + MI<br>**FIBT** + MI<br>**FIBINS** + MI<br>**FIBSOL** + MI<br>**FIBT** + MI<br>**FIBC** + MI |
| **Ash** | **ASH**: ash | g | **Ash**<br>• Ash values are used in internal checks on the sum of proximates, in the calculation of available or total carbohydrates, by difference. Therefore, it should be part of the archival and reference DB, but is often not included in a concise user table/DB. Ash values should be reported, if carbohydrates are calculated by difference. If no ash value is available, an ash value needs to be estimated from a similar food<br>• Ash values give an approximation of the total inorganic material<br>**Inorganic constitutes**<br>Sodium, potassium, calcium, magnesium, iron, zinc etc. should be part of a concise user table/DB. Iodine and selenium should be included if they are a public health concern | **ASH** |

| | | | | |
|---|---|---|---|---|
| **Vitamin A and pro-vitamins** | **VITA_RAE**: vitamin A; calculated by summation of the vitamin A activities of retinol and the active carotenoids.<br>Total vitamin A activity expressed in mcg retinol activity equivalent (RAE) = mcg retinol + 1/12 mcg ß- carotene + 1/24 mcg other provitamin A carotenoids<br>(or RAE = mcg retinol + 1/12 mcg ß- carotene equivalent)<br>**VITA**: vitamin A; calculated by summation of the vitamin A activities of retinol and the active carotenoids.<br>Total vitamin A activity expressed in mcg retinol equivalent (RE) = mcg retinol + 1/6 mcg ß-carotene + 1/12 mcg other pro-vitamin A carotenoids<br>(or RE = mcg retinol + 1/6 mcg ß- carotene equivalent)<br>**CARTA**: alpha-carotene.<br>All-trans alpha-carotene only<br>**CARTB**: beta-carotene.<br>All-trans beta-carotene only<br>**CRYPXB**: beta-cryptoxanthin<br>**CARTBEQ**: beta-carotene equivalents. This value is the sum of the beta-carotene + 1/2 quantity of other carotenoids with vitamin A activity.<br>β-carotene equivalent = 1 β-carotene + 0.5 α-carotene + 0.5 β-cryptoxanthin | mcg | **Vitamin A**<br>• Total Vitamin A (VITA_RAE) or total vitamin A (VITA) are the recommended definitions to be used in user tables/DB<br>• Vitamin A expressed in international units (IU) is obsolete and should not be used any more; however, if IU are used, it must be explicitly stated<br>• For conversion from IU to mcg retinol, β-carotene or other provitamin A carotenoids and vitamin A in RE and RAE see FAO/INFOODS Guidelines on Conversion among different units, denominators and expressions (FAO/INFOODS, 2012a)<br>**Retinol**<br>• In the UK, for retinol 'All-trans retinol equivalent' in mcg is used = mcg all-trans retinol + 0.75 mcg 13-cis retinol + 0.90 mcg retinaldehyde<br>**β-carotene/ β-carotene equivalent**<br>• It would be best to phase out β-carotene equivalents in favour of reporting individual carotenes and vitamin A<br>• In archival and reference DB, β-carotene equivalent should not be listed alone in the DB, but together with all contributing components<br>• In the user tables (CARTBEQ) might be better to state, as it is more comprehensive, and in user DB (CARTBEQ) should be accompanied by α-carotene, β-carotene and β-cryptoxanthin<br>• Components that are needed to calculate Vitamin A values: retinol, β-carotene, α-carotene, β-cryptoxanthin, their conversion factors to calculate VITA, VITA_RAE and CARTBEQ (β-carotene equivalent is not needed, if values for the single provitamins are given in the DB)<br>Lutein, lycopene and zeaxanthin do not have vitamin A activity | **VITA** + MI + unit<br><br><br><br><br><br><br><br><br><br>**VITA** + MI + unit<br><br><br><br><br><br><br><br><br><br>**CARTA**<br><br>**CARTB**<br><br>**CRYPXB**<br>**CARTBEQ** |

(*Continued*)

**Table 5.2** (*Continued*)

| Component | INFOODS tagnames | Unit* | Comments | European Food Information Resource (EuroFIR) component identifiers (MI = method indicator) |
|---|---|---|---|---|
| **Vitamin D** | **VITD**: vitamin D; calculated by summation of ergocalciferol and cholecalciferol. This definition is mostly used | mcg | • VITD is mostly used; some DBs also use VITDEQ (e.g. Danish or British food composition databases)<br>• Vitamin D expressed in IU is not preferred; however, if used IU must be explicitly stated<br>IU divided by 40 should be the value for vitamin D reported in mcg (1 IU vitamin D = 0.025 mcg vitamin D (VITD)/vitamin D3 (CHOCAL). See also FAO/INFOODS Guidelines on Conversion among different units, denominators and expressions (FAO/INFOODS, 2012a) | **VITD** + MI |
| | **VITDEQ**: vitamin D; Vitamin D3 + D2 + 5 × 25-hydroxycholecalciferol | | | **VITD** + MI |
| | **VITDA**: vitamin D; determined by bioassay. The nutrient values are generally higher than the values determined chemically | | | **VITD** + MI |
| | **ERGCAL**: ergocalciferol (D2); occurs in plant foods | | | **ERGCAL** |
| | **CHOCAL**: holecalciferol (D3); occurs in animal foods | | | **CHOCAL** |
| | **CHOCALOH**: 25-hydroxycholecalciferol | | | **CHOCALOH** |
| **Vitamin E** | **VITE**: vitamin E; calculated by summation of the vitamin E activities of the active tocopherols and tocotrienols; expressed as α-tocopherol equivalents<br>= α-tocopherol + 0.4 ß-tocopherol + 0.1 γ-tocopherol + 0.01 δ-tocopherol + 0.3 α-tocotrienol + 0.05 α-tocotrienol + 0.01 γ-tocotrienol **(mostly used)**<br>= α-tocopherol + 0.5 ß-tocopherol + 0.1 γ-tocopherol + 0.3 α-tocotrienol<br>= α-tocopherol + 0.4 ß-tocopherol + 0.1 γ-tocopherol + 0.01 δ-tocopherol | mg | • Generally user tables/DB use VITE. However, some user tables/DB report TOCPHA (e.g. USDA)<br>In archival and reference DB, vitamin E (VITE) should not be listed alone in the DB, but together with all contributing components<br>It should be noted that the latest version of the DRIs published by NAS/IOM state that α-tocopherol is the active form of vitamin E and that the use of α-tocopherol equivalents is discontinued | **VITE** + MI |
| | **VITEA**: vitamin E; determined by bioassay | | | **VITE** + MI |
| | **TOCPHA**: α-tocopherol | | | **TOCPHA** |
| **Niacin** | **NIA**: niacin, preformed | mg | Total niacin equivalent (NIAEQ) = niacin preformed (NIA) + 1/60 tryptophan (TRP) | **NIA** |
| | **NIAEQ**: niacin equivalents, total. Preformed niacin plus niacin equivalents from tryptophan | | | **NIAEQ** + MI + unit |
| | **NIATRP**: niacin equivalents, from tryptophan. 1/60 × tryptophan | | | **NIATRP** |

| | | | | |
|---|---|---|---|---|
| **VIT B6** | **VITB6C**: vitamin B6, total; calculated by summation. Pyridoxal plus pyridoxamine plus pyridoxine | mg | | **VITB6** + MI |
| | **VITB6A**: vitamin B6, total; determined by analysis | | | **VITB6** + MI |
| **Folate** | **FOL**: folate, total. Includes both conjugated and free folate (determined by microbiological assay). Folate, total: food folates + fortified folic acid (if any) in processed food | mcg | • FOL is the recommended expression and generally yields higher values than FOLSUM<br>• FOLFD is to be used if FOL, FOLAC and/or FOLDFE are also reported. This is to distinguish the folate content in the food from the fortificant amount | **FOL** + MI |
| | **FOLSUM**: folate, sum vitamers. It includes mostly tetrahydrofolate, 5-methyltetrahydrofolate, 5-formyltetrahydrofolate, 10-formylfolic acid, 10-formyldihyrdofolate and folic acid (determined by HPLC) | | | **FOL** + MI |
| | **FOLAC**: folic acid, synthetic folic acid used in fortification | | | **FOLAC** |
| | **FOLFD**: folate food, naturally occurring food folates (determined by microbiological assay) | | | **FOL** + MI |
| | **FOLDFE**: folate, dietary folate equivalents. = food folate + 1.7 × synthetic folic acid | | | **FOL** + MI |
| **Vitamin C** | **VITC**: vitamin C. L-ascorbic acid plus L-dehydro-ascorbic acid. Usually analysed by HPLC | mg | • VITC generally yields highest values. In fresh food, however, VITC and ASCL should give comparable results, since the oxidised form of VITC, if existing, is very low | **VITC** |
| | **ASCL**: L-ascorbic acid. Titrimetry can only analyse L-ascorbic acid | | • In fresh foods the reduced form (ASCL) is the major one present, but the amount of the dehydro-form (ASCDL) increases during cooking and processing | **ASCL** |
| | **ASCDL**: L-dehydro-ascorbic acid (=oxidised form of VITC) | | | **ASCDL** |

*Recommended unit.

conversion factor – whereas other compilers provide the analytical data for the individual components, in addition to the calculated components. This latter practice should be encouraged, since conventions for calculating these values based on biological activity change, and many of these individual components, have other functions in addition to their roles as provitamins.

In data compilation, all available food composition data can be included in the database. Complete information for all components in all foods is not necessary. Ideally, a database should have complete information for selected 'core' nutrients, but should also be able to accommodate miscellaneous data for other components in the foods listed.

The early work of INFOODS included the development of standards and guidelines for compiling food composition databases for national and regional use (Rand *et al*. 1991), standards for unambiguously identifying food components (Klensin *et al*. 1989) and standards for ensuring international comparability and interchange of food composition data (Klensin 1992). These standards are being maintained and further developed by INFOODS expert committees and consultative groups (see the INFOODS website, http://www.fao.org/infoods/en/).

## *Data dissemination*

With appropriate data compilation, food composition data can be disseminated in many different forms to satisfy all user requirements. Data disseminated as a set of relational files offers users with very specific needs, or those with customised software, the opportunity to use the data as they wish. Other common dissemination formats include printed abridged and unabridged publications, web-accessible databases, spreadsheet or PDF files, all of which provide different levels of information required by different user groups.

## *Data use*

Food composition data are the basic, most fundamental information resource for most nutrition activities. Some of the specific uses of food composition data, along with examples of their uses, are listed here by sector.

### Health

Food composition data are used in *health protection* or food safety activities in most countries in the world. 'Food control' laboratories monitor mostly harmful components of foods. Other health protection activities include food composition activities involving total diet surveys or 'market basket surveys' designed to determine the risk to populations from intakes of selected nutrients, anti-nutrients and contaminants. The sampling, sample preparation, sample handling, analyses and reporting requirements are virtually identical to the requirements of other food composition activities.

*Health promotion* activities include campaigns aimed at reducing or increasing the intake of certain nutrients in certain populations. Examples include healthy heart campaigns, typically using energy, fat, fatty acid and cholesterol compositional data, to educate the public about diet-related cardiac morbidity and mortality. In many developing countries, health promotion focuses on micronutrient data, including the necessity for including iodine in salt and provitamin A carotenoids from fruits and vegetables.

Food composition data are central to *clinical care and clinical research* trials. Examples include studies focusing on amino acid digestibility in ileostomy patients, vitamin A intake in breast-fed infants and serum cholesterol levels in vegetarians. Knowledge of the composition of the test and control food(s) and/or diet(s) is fundamental to these studies. Clinical dietitians must know the composition of foods in order to provide meals in a clinical setting. Special diets for patients are often based on individual nutrients in the foods: low-sodium diets for hypertensive patients, diets low in saturated fats for heart disease patients, diets containing proper ratios of protein, fat and carbohydrate for diabetics, high-protein diets for burn patients, diets containing low phenylalanine for phenylketonuric patients and so forth.

*Nutritional epidemiology* addresses food intakes and relates them to the nutrient content of the diet and the incidence of diseases. Dietary intake studies and food consumption surveys (e.g. food frequency questionnaires, diet histories, 24-hour recalls, food diaries, household budget surveys) derive their most important interpretations from food composition data, whether the issue is diet-related chronic diseases or intakes of individual nutrients.

Many *public health policies* relating to non-communicable disease focus on food composition. Such policies set forth nutrition goals and guidelines and include recommended dietary intakes (RDI). An example of such goals and guidelines is 'Choose a diet low in fat, saturated fat and cholesterol'; an example of an RDI is 'Females between the ages of fourteen and eighteen should get 15 mg of iron daily'. In order for such recommendations to be useful, both health professionals and the public must have access to data on the nutrient composition of foods.

*Nutrition interventions* may take the form of fortification of the food supply or supplementation of the population. Examples of food fortification include the addition of iodine to salt (most countries), vitamin A to sugar (for example, in Guatemala) and addition of minerals and B vitamins to refined cereal products (USA, UK).

It also includes nutrients in the form of injections, sprinkles and ready-to-use therapeutic formulations. Such interventions should only be made after the nutrients in the food and water supply of a country or community have been studied, and a baseline position has been established and carefully monitored over a period of time.

Food security, and more recently food and nutrition security, is an issue that spans several sectors. Knowledge of the nutrient content of the foods in a country's food supply, and those consumed by a household, is a precondition for assessing national and household food and nutrition security.

*Consumers*' awareness of nutrition is very high and consumers are demanding more and better food composition data, whether it be from food labels or other sources. The internet offers many sites where consumers can enter their food consumption details, for example food source, portion size, frequency of consumption, and receive analyses of their nutrient intakes compared to nutrient requirements and/or nutrient reference values. Often the food composition data supplied is that of the USDA Standard Reference, which does not have worldwide applicability.

### Agriculture

The intensive livestock industries require accurate nutrient composition data on the feeds used. These data are generally far more extensive than those required for human foods, and include many micronutrients and individual amino acids. 'Performance' in these animals usually refers to weight at time of slaughter; muscle tissue to fat tissue ratios; and, in the case of milk-producing animals, an accurate profile of the proximate composition (protein, fat, lactose, water and ash).

National and global food and nutrition security is generally considered an agriculture-sector issue related to food production, rural development, irrigation, fertiliser and pesticide use, crop yields and so on. A common tool used to assess national and global food and nutrition security is the FAO food balance sheets, which examine, at the commodity level, the amount of food available to a country. The amount of food is then converted into individual components and reported as the amount of protein, fat and energy available per person per day from the domestic food supply. Food composition data assigned to the commodity data are the basis for many food and nutrition security assessments, including FAO's yearly report on the number of under-nourished people in the world.

The agriculture sector is responsible for ensuring that food exports meet the regulatory requirements of the intended market. Food composition data are important, as product specifications (for example, the fat content of butter) and as nutrition label panels.

Agriculturalists have long professed that malnutrition is not merely a health problem, but also an agriculture problem. Increased consumption of imported food commodities has brought about changes in food patterns and diets that have contributed to the increase in certain diet-related health problems previously unheard of in certain parts of the world. Agricultural extension workers are combating the incidences of diet-related diseases in some developing Pacific Island countries by using nutrient composition data in family food production, helping families in designing home garden projects to supply nutrients that would otherwise be consumed in insufficient quantities.

Breeding has been carried out to modify certain nutrients in foods. Familiar examples include corn bred for higher lysine and cattle bred for a lower fat content of the carcass.

### Environment/biodiversity

In the past, generic food composition data were considered sufficient for most purposes. Now there is more awareness of the need for carrying out food composition studies that take biodiversity into account – that is, at the taxonomic level below species (e.g. variety, cultivar, and breed). Thousandfold differences are not uncommon, for example in different cultivars of fruits. Some important authorities and processes have acknowledged the importance of differentiating not only between species, but also between cultivars and varieties of the same species. With respect to rice varieties, the International Rice Commission has recommended the following:

- The existing biodiversity of rice varieties and their nutritional composition need to be explored before committing to transgenic varieties of rice.
- Nutrient content needs to be among the criteria in cultivar promotion.
- Cultivar-specific nutrient analysis and data dissemination should be systematically undertaken.
- The evaluation of the composition and consumption of rice cultivars should continue for the development of food biodiversity indicators to guide agro-biodiversity conservation and human nutrition.

Other bodies have emphasised the importance of undertaking food composition work at the level of the genetic resource, including FAO, Bioversity International, the Convention on Biological Diversity, the Commission on Genetic Resources for Food and Agriculture, INFOODS and its regional bodies, and more. To facilitate this endeavour, FAO has developed the FAO/INFOODS Food Composition Database for Biodiversity (BioFoodComp) as a global repository of nutrient data on food biodiversity to support the evidence basis on the nutrient content of food biodiversity. This database includes analytical data on

nutrients and beneficial bioactive non-nutrients for plant varieties/cultivars and animal breeds as well as for neglected and underutilised species and wild foods. The entire database can be downloaded free of charge from the INFOODS website (http://www.fao.org/infoods/en/) and users are able to easily incorporate these data into national or specialised food composition databases.

Knowledge of the nutrient composition of the native diet of endangered animal species is an important requirement for protecting them. In New Zealand, scientists have undertaken studies to determine the nutrient composition of the original diets of birds in their native habitat, to ensure that the same nutrients in the same quantities and proportions were being supplied in their human-made offshore island sanctuaries and other protected, artificial habitats.

Climate change also influences food composition. Ozone depletion affects both food production and the composition of crops and agricultural products. Like ozone depletion, global warming affects agriculture in terms of production implications. Its other major effect, now and in the future, is the creation of conditions that will permit certain food products to be cultivated where temperature conditions did not permit their cultivation previously. This will alter the food supply, and along with it the nutrient composition of certain foods in certain countries. Food composition data have been used as markers in modelling and predicting environmental change, for example monitoring the changes in fatty acid composition of fish to chart the climatic phenomenon of El Niño.

### Trade

Trade has emerged in recent years as one of the more important and demanding of the sectors involved in food composition activities. Food composition in various forms features in World Trade Organization agreements, the Codex Alimentarius Commission and several of its committees, multilateral and bilateral trade agreements, and national food regulations and standards. More than other sectors, trade has illustrated most poignantly the need for standards and harmonisation in technical food composition activities. Many trade-related court cases have involved food composition data, both in the charges filed and in evidence presented, and many of the food product detentions and rejections at US borders are due to the absence of the Nutrition Facts panel of nutrient content data.

## 5.5 Limitations

A common limitation in food composition data is the lack of statistical reliability of the resultant values. Ideally, a sampling protocol should be designed for representativeness, with a sufficient number of independent samples collected and analysed, and a sufficient number of analytical replicates for each sample to ensure precision. Too often, mainly for reasons of financial limitations, only a single sample is collected and analysed. Documentation needs to include, at the very least, the number of samples analysed (n) for each value and, presuming n = 3 or more, the variation (e.g. a standard deviation) around the central value. Sometimes the reasons for differences are empirical – they relate to differences in methodology, for example in dietary fibre analyses, or in the form of the nutrient, for example total folate vs folic acid. INFOODS tagnames provide much of the necessary documentation to avoid empirical confusion.

Even when a comprehensive sampling and analytical programme is in place, there can be many reasons why the actual nutrient content of a food is different from the data provided in food composition databases. The reasons can often be understood when proper and complete food descriptors are provided – for example, the dietary fibre content related to the part of a plant such as peas with or without pod; processing related to vitamin B enrichment of flour; vitamin C differences with stages of maturity of mangoes; different fat contents for different grades of beef; or beta-carotene differences among different cultivars of sweet potatoes. Part, process, maturity, grade and scientific name (genus, species, variety) should all be part of a food name in a well-documented food composition database.

Even with appropriate metadata, with details of sampling, sample handling and preparation, analytical method and conditions, there will still be limitations in all food composition databases. This is a feature of the rapidly changing food supply, the heterogeneity of agricultural conditions (e.g. soil composition) and practices (use of agricultural chemicals), climatic conditions, seasonal variations, animal husbandry and food regulations (e.g. fortification policies). However, in spite of these limitations, food composition databases are indispensable tools for nutritionists operating in all sectors.

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