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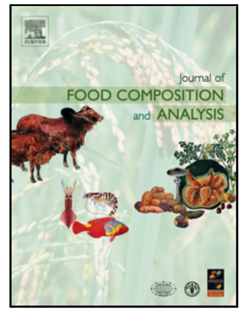

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Research article

Nutrition Indicator for Biodiversity on Food Composition - A report on the progress of data availability

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Abstract

FAO in collaboration with Bioversity International is leading the *Cross-cutting Initiative on Biodiversity for Food and Nutrition* which has been established to measure, investigate and promote biodiversity and nutrition. Nutritional indicators for biodiversity are needed to address the diversity of plants, animals and other organisms used for food, covering the genetic resources within species, between species and provided by ecosystems. The indicator for food composition aims to report the annual progress regarding availability of food compositional data for biodiversity from different data sources by counting the number of foods with sufficient detailed description of genus, species, subspecies and

variety/cultivar/breed and with at least one component. Since the development of the nutrition indicator for biodiversity on food composition in 2007 more than 10 000 foods have been counted for the indicator. A 54% increase in data availability was measured from 2008 to 2009. Due to the mode of searching most data were located in scientific articles. Most available data were on variety/cultivar/breed level and were from Asia (3741) followed by America (2297), Africa (1773), Europe (1541) and Oceania (1032). This research supports the increasingly recognized importance of biodiversity for food composition. Nevertheless a wider spectrum of foods and components need to be analysed in order to mainstream biodiversity into nutrition activities.

Introduction

A wealth of botanical and agricultural diversity exists. It is estimated that over 7000 plant species used for food can be found across the world (Bioversity International, 2009). However, during the last decades, a decline in mean species abundance of 30 % has been reported (Nunes and Nijkamp, 2008). Only three crops, maize, wheat and rice, contribute to 43 % of the global requirements for energy and to 39 % of the global requirements for protein (FAOSTAT, 2010). This one-sidedness of agriculture contributes to a reduced consumption of other nutritionally rich species and varieties such as fruits and vegetables (Johns and Eyzaguirre, 2006). The global food and nutrition security becomes vulnerable when it is dependent on only a few number of species (Flyman and Afolayan, 2006). All the dimensions of food and nutrition security need to be addressed in interventions. Therefore, not only the quantity and energy contribution of foods are important to combat malnutrition but also their quality, i.e. their micronutrient content (Toledo and Burlingame, 2006). Vitamin A, iron and iodine deficiencies represent a serious global health problem (WHO, 2009b). Supplementation and fortification are common approaches to combat these deficiencies (Flyman and Afolayan, 2006). This ignores the fact that these three nutrients are simply markers for more extensive nutrient deficiencies and neglect the importance of a mixed diet including local varieties and underutilized foods. An alternative and more sustainable solution can be achieved by focusing on agro-biodiversity and food biodiversity (Johns and Eyzaguirre, 2007).

Food biodiversity is defined as the diversity of plants, animals and other organisms used for food, covering the genetic resources within species, between species and provided by ecosystems (FAO, 2010). The fact that nutrient content of food is significantly affected by the cultivar, variety or breed has lately become increasingly acknowledged and documented. In different varieties of the same species, the composition of macronutrients can vary by 10-fold and micronutrients by up to 1000-fold, representing the same variation as found between species (Burlingame et al., 2009; Davey et al., 2009; de Faria et al., 2009; Englberger et al., 2009; Talpur et al., 2009; Vieira et al., 2009). The intraspecies biodiversity has together with wild and underutilized foods a key role in global food and nutrition security (Nesbitt et al., 2009). Recent compositional studies show that locally available cultivars, varieties and wild underutilized foods are in many cases more nutrient-rich than similar commercially available foods, partly due to size of the food, water content and monoculture (Du et al., 2009; Giovanelli and Buratti, 2009). Nutrient content of cultivars/varieties/breeds should therefore be an important factor to consider in nutrition education and in agricultural research and strategies (Flyman and Afolayan, 2006; Toledo and Burlingame, 2006). Thus, biodiversity can contribute to achieving the Millenium Development Goals 1 and 7: “Halve the proportion of people who suffer from hunger” and “Ensure environmental sustainability” (UN, 2000).

Compositional data on food biodiversity is of importance not only for nutrition and health, but also for other areas. The concept of substantial equivalence “embodies the idea that existing organisms used as food, or as a source of food, can be used as the basis for comparison when assessing the safety of human consumption of a food or food component that has been modified or is new.” It involves a targeted analysis of the composition of genetically modified organisms (GMO) compared with their conventional counterparts. The major limitation of profiling is the need to accommodate the background of normal variation and to interpret the significance of any differences detected. Moreover, a broad spectrum of compositional data, covering the diverse varieties/cultivars/breeds, could identify existing organisms with high nutritional qualities and thus create an alternative to expensive research in GMO (Burlingame, 2004).

In addition, better knowledge of nutritional composition for unique species and varieties is essential for expansion of trade since many countries by legislation require accurate labelling of foods (Toledo and Burlingame, 2006).

Due to little attention to nutrient content among cultivars, varieties, breeds and underutilized foods, large gaps exist globally in food composition and food consumption data for these foods (Johns, 2003; FAO, 2010). In order to include this central aspect in nutrition programmes and interventions, food composition and food consumption investigations need to be enlarged to cover the existing biodiversity. These data should be gathered and disseminated to potential users e.g. through food composition databases and in food consumption reports. Only when the two elements, food composition and food consumption, are known, the contribution of biodiversity to better nutrition and health can be investigated and valued (FAO, 2008; FAO, 2010).

The *Cross-cutting Initiative on Biodiversity for Food and Nutrition* has been established to measure, investigate and promote biodiversity and nutrition. It is led by FAO (Food and Agriculture Organization of the United Nations) in collaboration with Bioversity International and other partners. One of its tasks was to establish nutrition indicators for biodiversity. The first indicator on food composition, to be referred to as the indicator within this article, was developed in 2007 at an Expert Consultation in Brazil (FAO, 2008). FAO will report, on a yearly basis until 2015, on the availability of food composition data for biodiversity. Data included for this purpose are foods with a taxonomic description below species level and wild and underutilized foods. More specifically, the indicator is a count of the number of foods fulfilling the criteria for biodiversity with at least one food component (Biodiversity Indicators Partnership, 2009; FAO, 2008). Another nutritional indicator for food biodiversity was developed in 2009, this time on food consumption. It will monitor the availability of food consumption data counting for biodiversity (FAO, 2010). The objective of the two nutrition indicators for biodiversity is to stimulate the production, collection and dissemination of food composition and consumption data taking biodiversity into account. In this way, the contribution of biodiversity to nutrition and health and other areas can be investigated and used to more accurately calculate nutrient intake estimations and dietary adequacy. Moreover, the indicators can be used as an advocacy tool to promote awareness of the importance of food biodiversity, including wild and underutilized foods. They will ultimately contribute to nutrition security, and the conservation and sustainable use of food biodiversity.

The aim of this article was to evaluate the trend of the indicator between 2008 and 2009 in terms of data availability, origin, location, food groups and components.

Materials and Methods

<u>The Indicator</u>

The indicator is a count of the number of foods with a satisfactory description on taxonomic rank below species with at least one value for a nutrient or a bioactive component. Exceptions exist for foods that are considered wild or underutilized, for which information on the species level is accepted. Indigenous foods were at first included for the indicator, but this term was excluded for the indicator in 2009, as it was often interpreted to incorporate common foods of local origin. As the term "underutilized food" is not well defined, it was decided in 2009 to only count those foods which are included in the specifically developed food list for this purpose: the 'reference list for underutilized foods for food biodiversity' which can be found on the website of the Global Facilitation Unit for Underutilized Species (GFU) at http://www.underutilized-species.org/species/about_species.asp (GFU, 2010).

The indicator focuses on the genetic variety of foods while excluding other factors influencing the composition of foods such as environment, region, season, processing, feed and agricultural practices. Table 1 gives an overview of the criteria used for inclusion or exclusion of foods counting for the indicator.

<u>Data Sources</u>

Data for the indicator were obtained through peer-reviewed articles, books, reports from e.g. research institutes, theses, conference presentations (including posters) and food composition databases. The search engines Scopus and Science Direct were used to obtain scientific articles. Electronically available search engines and non-electronic registries of universities were used to collect suitable theses. A targeted search for theses was conducted for Africa, Asia and South/Central America, whereas for Europe and Oceania the search was not as intensive. The search terms included food composition, composition, biodiversity, variety, cultivar, breed, wild food and underutilized species in different combinations. Specific searches were conducted for fruits, potatoes and milk. Reference lists of relevant papers were cross-checked and any suitable additional articles were included.

Data were also obtained through the INFOODS (International Network of Food Data Systems) mailing list, especially INFOODS regional data centre coordinators, and through experts having attended the Expert Consultation. Compilers sent information of their published user food composition databases, as well as from their unpublished reference databases. No limitations concerning the year of publication were set.

Data processing

All data obtained before February 2008 are considered baseline data. All data obtained afterwards but published before February 2008 are considered updated baseline data. Data published between February 2008 and December 2009 are considered for the reporting period of 2009. Each food that counted for the indicator was categorized according to the number of components analysed: 1, 2-9, 10-30 and >30 components. Moreover, other information was documented, such as reason for inclusion (<species level or because wild or underutilized) and geographical origin. For the data collected after February 2009, additional information on food names and group was recorded as well as on component names.

Compositional data for milk and potatoes were complied in a database and are available on the home page of FAO/INFOODS: http://www.fao.org/infoods/biodiversity/index_en.stm (FAO/INFOODS, 2010).

Results and Discussion

Since 2007 over 10 000 foods matching the criteria for the indicator were found. The baseline 2008 as well as the increase in data availability from 2008 to 2009 is shown in Figure 1. The increase in data availability counting for the baseline but found in 2009 is considered updated baseline data. The data search of 2009 increased the availability of data by 54 % out of which 70 % were for the baseline of 2008 and 30 % of data count for 2009. This shows that a high amount of compositional data on biodiversity already exists and it is expected that the baseline data will increase also in future reporting. A large number of data were found by cross-checking the reference lists of relevant literature sources and include publications as far back as 1970.

The collected data since the start 2007 show a large variation between continents (see Figure 2). Most data were found for Asia (3741) followed by America (2297), Africa (1773), Europe (1541) and Oceania (1032). An explanation for the differences among continents can be attributed to data availability (data generation and publication) and the intensity of data search. In America and Europe, most data are published through the scientific literature whereas in Asia an equally high amount is published in user food composition databases, theses, reports and scientific literature. In the other continents, fewer data are published through food composition databases and other literature. Due to the search engines used, most data were found in scientific journals. More data were found in published food composition databases than in other literature (books, posters, thesis, no-peer-reviewed articles).

In general, food composition databases contained a small amount of data on biodiversity. Australia and Thailand presented the highest number of biodiversity foods in user databases, 536 and 319, respectively. However, there are several databases which will contain biodiversity data as they are already included in the unpublished reference databases (e.g. Bangladesh, Malaysia and USA) and could be published in subsequent editions. In contrast, the whole continent of Europe showed an availability of only 74 foods included in user databases of Sweden, Italy and Greece.

In the category other literature, a special search was carried out in Africa, Asia and South/Central America for theses and reports (e.g. from research institutes), which explains the relatively high contribution of the category other literature in these continents. Altogether, theses contributed 830 foods followed by reports from research institutes (407 foods) and books (348 foods). Few data were found in Europe and Oceania, probably also because a less intensive search was carried out.

The information on food groups and components presented below derives from 50 % of the total data collected because before 2008, recording was limited to counts of foods without providing a food list or list of components.

As shown in Figure 3, 89 % of foods were described below species level and 11 % were wild and underutilized foods. The main reason for the small contribution of this group is probably because underutilized and wild foods often are neglected and considered emergency foods in times of crisis rather than a contributor to a regularly consumed diet (McBurney et al., 2004). They are therefore rarely analysed, hence their nutrient composition does not appear in the scientific literature. Moreover, they receive little attention from botanists, and are thus not always taxonomically described. Instead, they are often known under one or several local names (Nesbitt et al., 2009).

The identification of foods was not always evident from the literature, especially of wild and underutilized foods. Sometimes, foods were described only with a vernacular name, which could refer to a variety or cultivar, or to a species. This and other problems encountered when including foods for the indicator made it necessary to develop specific criteria (see table 1) to assist users in the decision to include or exclude foods for the indicator.

Significantly higher amounts of data were available for plant foods compared to animal foods, 89 % and 11 % respectively. As presented in Figure 4, the food group with most available data was fruits and nuts, followed by tubers, cereals, vegetables and animal foods. Tubers included potato, yam, cassava and taro. Cereals included maize, rice, wheat, rye, barley, sorghum and millet. Vegetables included mushrooms, beans, leaves, stems and fruiting vegetables such as tomato, pepper and pumpkin. Animal foods included all foods of animal origin, but the majority of data were for milk. A reason for this result is that specific searches for fruits, potatoes, and milk were conducted whereas cereals, vegetables and foods of animal origin other than milk were obtained only through a general search using search terms such as “biodiversity and food composition” which resulted in a very limited amount of relevant data, while specifications such as “banana, variety or cultivar” or “goat, breed, milk” resulted in a significantly higher amount of data. It is therefore reasonable to believe that more data for the other food groups exist. Moreover, an explanation for the lower amount of animal data could be that papers on animal foods frequently assessed only one or a few breeds while papers with analytical data on plant species often included many varieties/cultivars.

Figure 5 gives an overview of the components covered in plant and animal foods. Antioxidants and vitamins were the most frequently analysed components in plant foods, 1935 and 1905 foods, respectively. This can be explained by the fact that fruits are promoted for their high content of antioxidants and vitamins and that antioxidants have gained increasing interest in nutrition, health and food science in recent years due to their claimed health benefits (Valavanidis et al., 2009). Vitamin C, E and β-carotene although having also antioxidant capacity were counted for vitamins. The majority of antioxidant components belong to the group of polyphenols. For foods of animal origin (i.e., milk), fat, including fatty acids, and protein, including amino acids, were the most analysed components, followed by lactose (presented as carbohydrates). The lack of analysed vitamins and minerals in animal foods is surprising since milk is known to be an important source for vitamin A, riboflavin, vitamin B_{12}, calcium and zinc (Buttriss, 2003).

Few foods have been analysed for a broad spectrum of components. As shown in Figure 6, the majority of foods were analysed for 2-9 or 10-30 components, which were often within one component group (e.g. fatty or amino acid profile or carotenoids) rather than covering a broad spectrum of components. In the category 2-9 components, Asia and America contributed most data (1749 and 1300 foods, respectively), followed by Africa (978), Europe (772) and Oceania (296). In the category 10-30 components, Asia contributed still the highest amount of data (642), followed by Oceania (630), America (601), Africa (552) and Europe (529).

Significant compositional differences in macronutrient and micronutrient content among varieties and cultivars could be found (see Table 2). For banana cultivars, a 1000-fold difference in ß-carotene was observed. Two to 10 fold differences in iron, zinc and calcium content among cereal varieties were documented. This supports the statement that intake of one variety instead of another can make the difference between nutrient deficiency and adequacy, especially of micronutrients (Burlingame et al., 2009).

It is important to examine nutrients in relation to their public health significance (Greenfield and Southgate, 2003). The availability of compositional data will support countries in promoting their local species and varieties, in improving nutrition and health status by increasing the food diversity from local surroundings and through planting more foods with higher micronutrient content (Burlingame et al., 2009).

The collected data were examined according to the key micronutrient deficiencies because a food-based approach is a sustainable way to combat these deficiencies (FAO/ILSI, 1997; Johns and Eyzaguirre, 2007). According to WHO (WHO, 2004; WHO, 2008; WHO, 2009a), vitamin A deficiency is most common in Africa, Asia and Oceania; iron deficiency in Africa, Asia and South America, whereas iodine deficiency is most widespread in Oceania, Europe and Africa. Table 3 shows for each continent the number of foods that were analysed for carotenoids/vitamin A, iron and iodine. Data on carotenoids and vitamin A were relatively abundant for Africa and Oceania while Asia had few data. Data on iron were mostly available in Africa, Oceania and Asia. Few foods were analysed for their iodine content and data existed only in Europe and Africa. However, foods containing the highest values of iodine are fish and shellfish and they were not specifically searched for in this investigation. For vitamin A and iron, the availability of compositional data did in general correspond well to the areas where the deficiency is most widespread. The actual amount of data is however low considering the vast areas with high prevalence of these micronutrient deficiencies.

Compositional data on biodiversity are important for food composition databases because these databases are used to estimate nutrient intakes, to establish dietary adequacy and diet-disease-relationships, to calculate nutrient content for labelling purposes, etc. In general, data published in user databases are year-round nation-wide average values while data on different seasons, locations or variety/cultivar/breed are rarely published, even if these data are stored in the reference database. The average values may hide large differences between varieties of the same species. Figure 7 shows the flow of data from unpublished literature to user databases, i.e., data are first generated and are available in unpublished reports; some of them might get published in the scientific literature. Both data sources are used by compilers to include data into the archival and/or reference database. A subset of these data are published in the user database, mostly those foods for which enough data points are available and which are thought to be of interest for users (Greenfield and Southgate, 2003). Therefore, a large amount of data in scientific articles and other sources are needed before values can be incorporated in user databases. Moreover, a broad coverage of food components is desirable. Missing values represent one of the major problems for users of food composition databases (Greenfield and Southgate, 2003; Leclercq et al., 2001). Users of food composition databases should be able to benefit from the significant variations in nutrient content among foods of the same species, which can only be done if these data are presented at variety or breed level in user databases. Most database compilers might not be aware of these specific user needs (Burlingame et al., 2009). As shown in Figure 2, few data on biodiversity were found in user databases, partly because the main focus of the search was on scientific journals, and partly because user databases do not cover biodiversity extensively (even though corresponding data might be stored in the reference database).

The utility of data, in particular for wild and underutilized foods, in user databases is also dependent on the identification of foods. It is important to establish a correct link between consumption data and compositional data, which can be facilitated by well established taxonomic names (Leclercq et al., 2001; Nesbitt et al., 2009). The nutritional value of wild and underutilized foods could be better recognized with improved taxonomic identification (Nesbitt et al., 2009).

Conclusions

With over 10 000 food items documented, this research shows that the importance of biodiversity for food composition is increasingly recognized and reflected in their wide publication in scientific articles, mostly covering a small selection of components. Before such data are published in user food composition databases, it is necessary to have a broad coverage of nutrients. This might be one of the reasons why user databases do not include many foods counting for biodiversity. In addition, not all compilers realize their importance in the national food supply.

A wider spectrum of foods and components, including for biodiversity, should be analysed and disseminated at regional level, especially for nutrients of public health concern. This includes main micronutrient deficiencies (vitamin A, iron and iodine) and diet-related risk factors for chronic diseases (e.g. sugar, *trans*- and saturated fatty acids and sodium) as well as preventive factors (e.g. vitamins, trace elements, n-3 fatty acids and phytochemicals). Compositional and consumption data, including for biodiversity, for regional and local foods are a prerequisite for successful food-based interventions and to investigate the contribution of biodiversity to nutrition and health. These data are also a prerequisite to determine the need for fortification and supplementation programmes. Enhancement of taxonomic identification of wild and underutilized species could increase their utility for users, facilitate the data generation, and thus enable the investigation of their contribution to nutrition and human health. More information on food composition and consumption will help to mainstream biodiversity into many more nutrition activities.

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Table 1: Criteria for the inclusion or exclusion of foods counting for the Nutrition Indicator for Biodiversity on Food Composition

Foods included	**Foods not included**

• Foods at cultivar/variety/breed level for common and imported foods (e.g. rice, banana, potato), preferably with scientific name.
• For those foods counting for the indicator:
    • different parts of plants (e.g. leaf, root, flower, stem, fruit) and animal (e.g. all muscle cuts count only once but all organs or visible fat count separately);
    • different stages (e.g. egg, larva and young/adult animal);
    • only raw foods; except if just the cooked form of this food is available.
• Ingredients, if they meet the criteria, used in:
    • recipes or processed foods (e.g. spices, condiments, micro-organisms and probiotics);
    • non-packaged form of botanical supplements/extracts (including beverages).
• Foods with the number of cultivars/varieties/breeds per species even if not described by taxonomic or local name (*Musa* spp. – 4 varieties).
• Wild (i.e. not cultivated/reared/farmed) and/or underutilized foods only described at genus/species level and/or with local name (e.g. "grasshopper"). The underutilized foods must be recorded on the 'list of underutilized species counting for food biodiversity'[1].
• A local name in addition to an English/Spanish/French or taxonomic name if it is indicative for a variety/cultivar/breed (e.g. in brackets after the English/Spanish/French name).
• Colour and/or shape describe the variety/cultivar/breed. Examples:
    • Pear, brown-skinned (*Pyrus* sp.);
    • Snake gourd (*Trichosanthes cucumerina*).
• Taxonomic varieties considered by error as a species when described with additional cultivar name. Examples are found in the text above.
• Genetically modified foods.
	• Common or imported foods (e.g. rice, banana, potato) described only at species level, even if other specification are given such as:
	    • region;
	    • country;
	    • season;
	    • colour as part of the food name (e.g. green beans) or as indication of processing (e.g. white or brown rice);
	    • shape (e.g. medium-size carrot);
	    • species name is followed by author (e.g. L. or Linn. [for Linnaeus], Mill.), which should not be confused with the cultivar/variety/breed name;
	    • local name.
	• Common or imported foods described only with local name.
	• Foods with unspecific name, e.g. "wild green leaves", "reef fish", "bushmeat".
	• Local name in addition to English/Spanish/French name seeming to be the translation of the food (i.e. not indicative of variety/cultivar/breed).
	• Processed foods or recipes.
	• Supplements, and plant or animal extracts in packaged form.
	• Fortified foods.
	• Taxonomic varieties considered by error as a species when described without an additional cultivar name. Examples are found in the text above.

The reference list for underutilized foods for food biodiversity can be found on the websites of the Global Facilitation Unit for Underutilized Species (GFU) at **http://www.underutilized-species.org/species/about_species.asp** or at the INFOODS website **http://www.fao.org/infoods/biodiversity/index_en.stm**.

Table 2: Nutrient differences among varieties (per 100g edible portion, raw)

Varieties	Fat, g	Protein, g	Iron, g	Ca, mg	Zinc, mg	ß-carotene , mcg	References
Rice		5.6-14.6	0.20-1.07		0.54-2.65		Sellappan et al., 2009, Karunaratne et al., 2008, Kennedy and Burlingame, 2003
Wheat			2.9-8.7	50.0-106.5	3.87-7.0		Nahapetian and Bassiri 1976
Potato		1.4-2.9	0.3-2.7			1-7.7	Burlingame et al, 2009
Banana	1.47-4.20	3.1-3.9	0.1-1.6	4.93-68.6	0.23-0.36	<1-8500	Adeniji et al., 2007, Wall, 2006, Englberger et al., 2003, Burlingame 2009
Pandanus						19-896	Englberger et al., 2003, Englberger et al., 2006
Papaya			0.29-0.46	9.8-20.4	0.07-0.09	60-810	Kimura et al., 1991, Wall, 2006
Mango		0.3-1.0	0.4-2.8			20-4320	Burlingame et al., 2009

Table 3: Number of foods analysed for carotenoids/Vitamin A, iron and iodine presented per continent

Continent	Number of foods analysed for		
	Carotenoids/vitamin A	Iron	Iodine
Africa	194	235	1
North America	125	112	0
South America	340	343	0
Asia	99	129	0
Europe	175	87	6
Oceania	196	23	0
Total number of foods with available data	1129	929	7

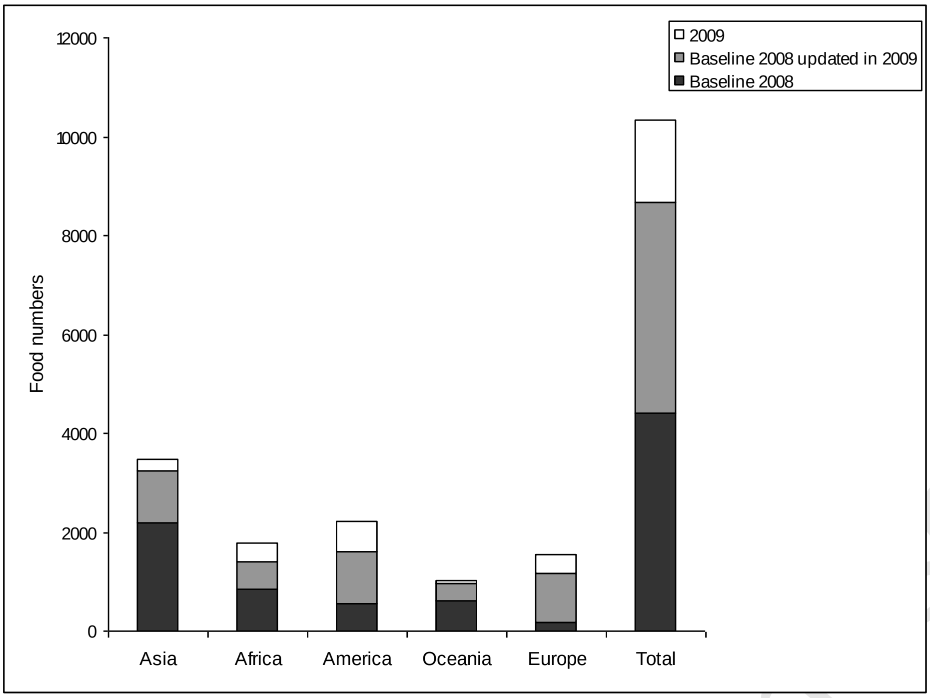

Fig. 1 Increase of data availability from 2008 to 2009

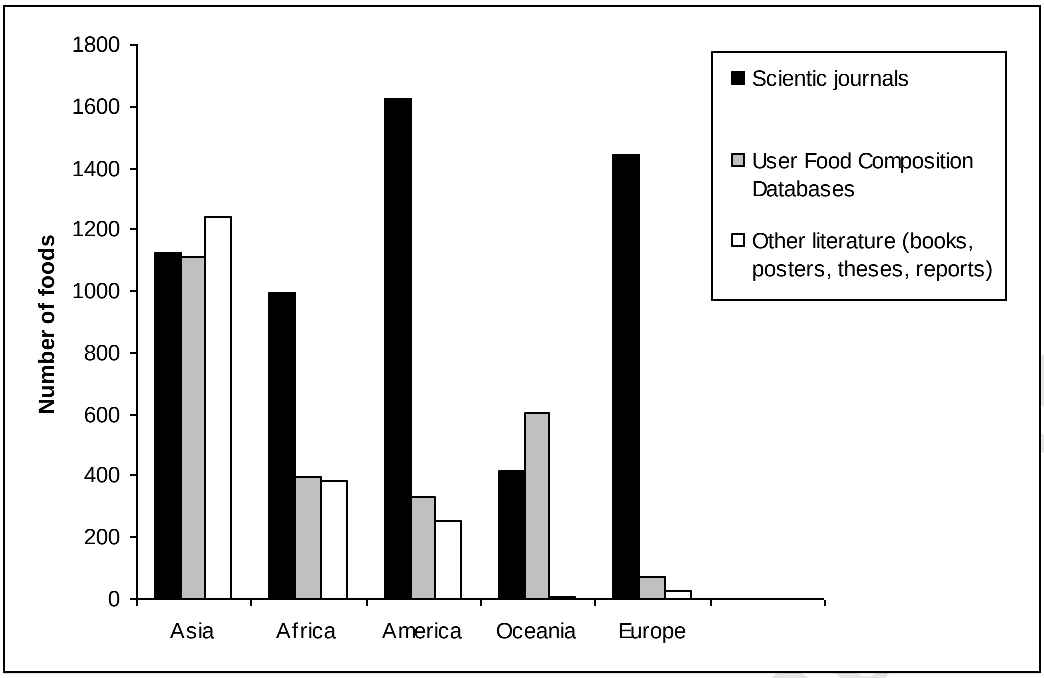

Fig.2 Cumulative number of available foods from different literature sources presented per continent (2008 and 2009).

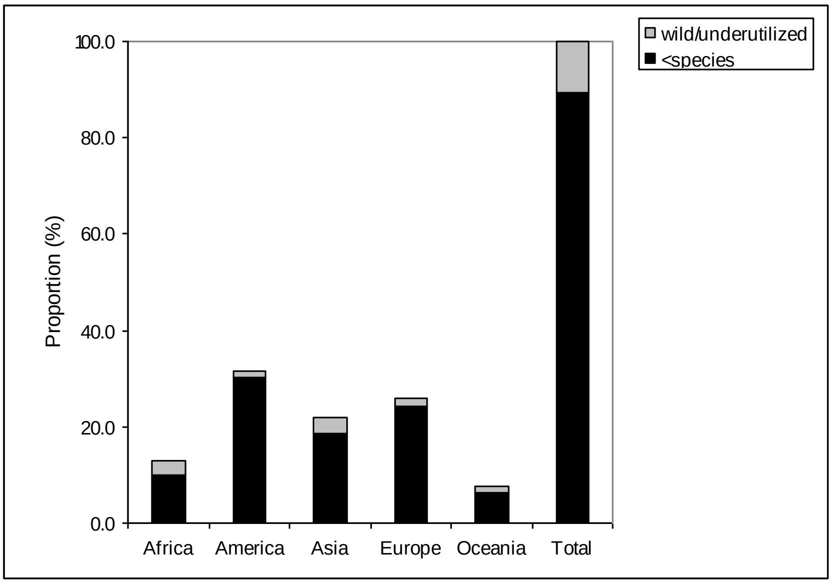

Fig. 3 Cumulative distribution of foods between <species level and wild/underutilized species presented per continent (2008 and 2009)

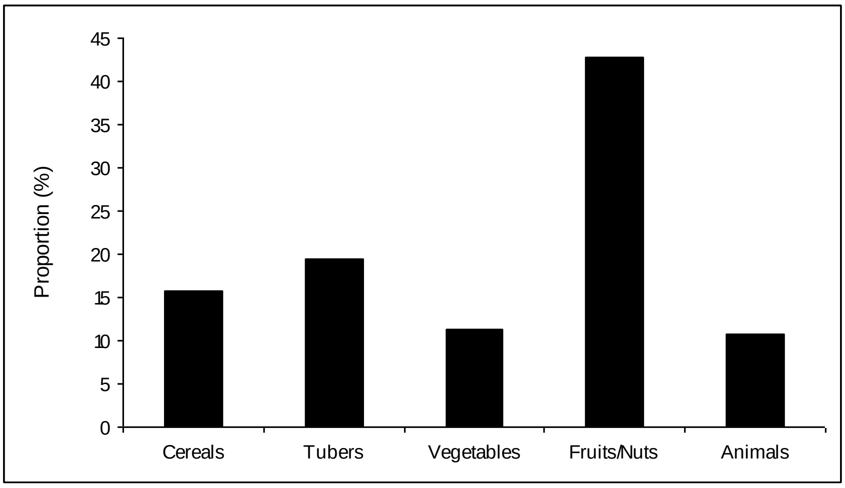

Fig. 4 Cumulative distribution of foods between cereals, tubers, vegetables, fruits/nuts and animals (2008 and 2009)

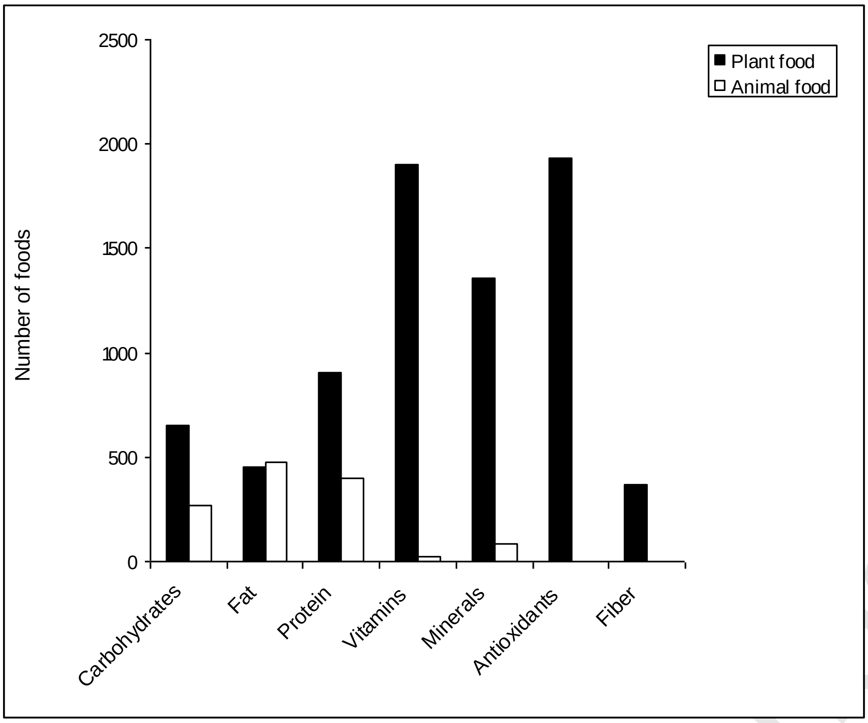

Fig. 5 Cumulative number of plant respectively animal foods analysed for carbohydrates, fat, protein, vitamins, mineral, antioxidants and fiber (2008 and 2009)

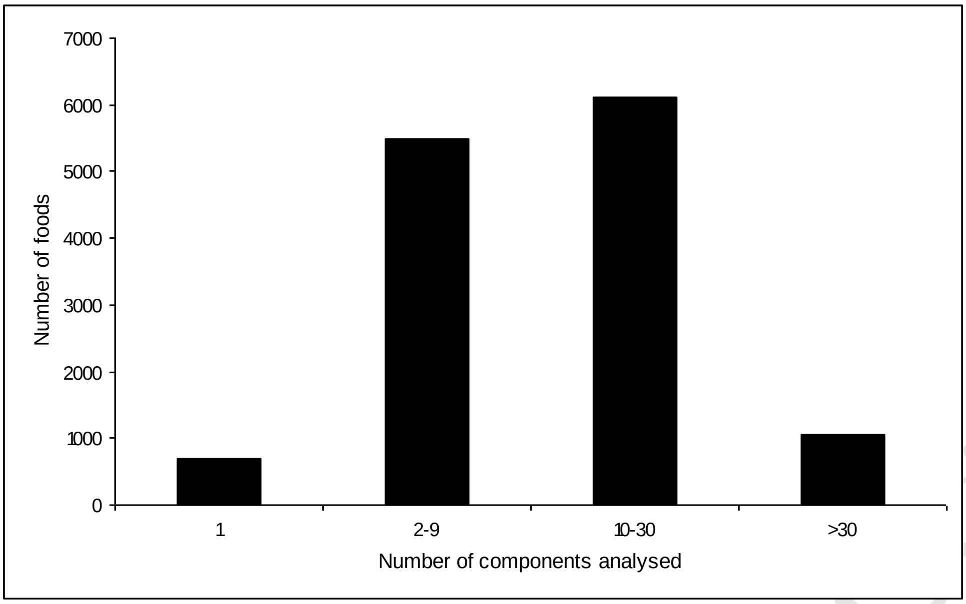

Fig. 6 Cumulative number of foods analysed for 1, 2-9, 10-30 and >30 components (2008-2009)

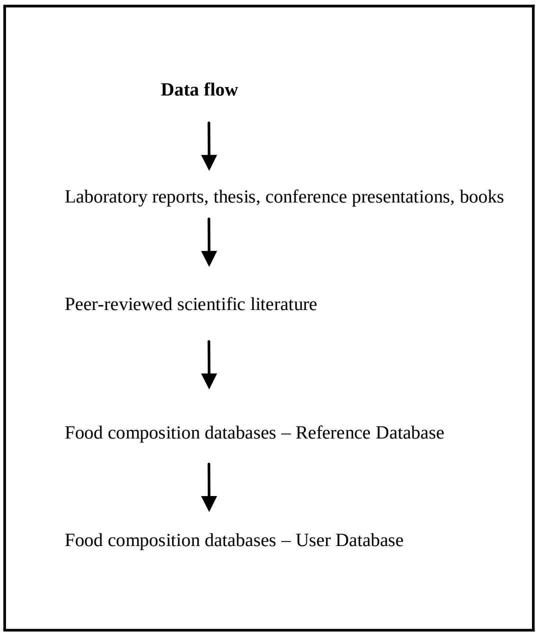

Fig.7 Data flow of food composition data