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Original Research Article

Update of the Moroccan food composition tables: Towards a more reliable tool for nutrition research

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ABSTRACT

The last food composition table (FCT) for Morocco was published in 1984 and has not been updated since. Our study aimed at bringing this FCT up to date, taking into account the current Moroccan population's diet. To collate nutrient information, we used the indirect method based on existing data published in the scientific literature. The primary data sources for compiling this table were local FCTs. International food composition data were used as an alternative source when Moroccan data were not available. This updated FCT includes information on 38 nutrient components, for 587 food items commonly consumed in Morocco. These foods represent an addition of 79 % of foods in the FCT. About 7 % of nutritional values were derived from Moroccan data sources and about 93 % from international sources, namely Tunisia, West Africa, France, UK, and USA. We were unable to find approximately 20 % of nutrient estimates. This updated FCT provides information on foods and dishes commonly consumed in Morocco and it can be used as a tool to foster nutritional research and to design public health strategies in Morocco. This work is a first step towards updating a standardized Moroccan FCT, which will need to be complemented with high-quality composition data.

1. Introduction

Food composition databases aim to provide comprehensive and representative information on the nutritional composition of foods (Church, 2015; Martinez-Victoria et al., 2015; Haytowitz and Pehrsson, 2018; Finglas et al., 2017). These tools are important for epidemiological research, public health, nutritional education and prevention, therapeutic diets, food safety, agriculture, food labeling and the food industry (Egan et al., 2007; Church, 2009; Bell et al., 2011; Cunningham et al., 2010). The availability and accessibility of food composition data are a prerequisite for analyzing nutrient intakes in surveys investigating the relationship between diet and diseases in population-based settings (Elmadfa and Meyer, 2010; Costa et al., 2013; Durazzo et al., 2019). Food composition data are also an essential source of information for developing dietary guidelines for different population groups as well as for food regulations and safety recommendations (Elmadfa and Meyer, 2010; Sammán et al., 2016; Uusitalo et al., 2011).

Food composition databases provide concentration values for energy and nutrients (e.g., protein, fat, carbohydrates, vitamins and minerals, water) and other important food components (e.g., fiber) per 100 g edible portion on fresh weight basis for each of the listed foods.

Abbreviations: CIRIHA, Information et de Recherche sur les Intolérances et l'Hygiène Alimentaires; FCT, food composition table; FAO, Food and Agriculture Organization; INFOODS, International Network of Food Data Systems; SFA, Saturated fatty acids; MUFA, Monounsaturated fatty acids (g); PUFA, Polyunsaturated fatty acids; USDA, the United States Department of Agriculture

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These values are either original chemical analytical values performed in analytical laboratories, imputed values, borrowed values, or calculated values (Williamson, 2005; Marconi et al., 2018; Black et al., 2011).

It is well known that dietary habits, and therefore the types of foods consumed, vary from country to country. Having culturally representative information on food intake and on consumption of nutrients and other bio-compounds intake in a population depends on the accuracy of both the dietary questionnaire and the food composition databases available (Sivakumaran et al., 2018; Pennington et al., 2007).

Morocco is a middle-income country with a nutritional transition characterized by profound changes in the way people eat, shifting from traditional dishes to more 'Westernized diets'. Morocco also experiences changes in the food production methods, e.g. from traditional towards more industrial food processing methods. In addition, there is a lack of data on nutrient composition of Moroccan foods. This critical issue increases the difficulty of analysis and interpretation of dietary data. The limited information on nutrient intakes in the Moroccan population and the paucity of studies investigating the relationship between diet and health might be partly explained by limitations in the availability of food composition databases.

To our knowledge, the first Moroccan food composition table (FCT) entitled "Food composition Table for use in Morocco" was published in 1977, by the Ministry of Agriculture of Morocco (El Khayate, 1984) and revised in 1984 by El Khayate R (El Khayate, 1984). Therefore, there is a pressing need to update and to supplement the information available in these FCTs with recent and reliable sources of food composition data.

The present work was carried out by a joint Moroccan and international multidisciplinary teams, is aimed at updating of the Moroccan FCT, containing data relevant to the Moroccan population and their current dietary habits. This FCT will be a useful tool for health professionals, dietitians, researchers, agriculturalists, food industry professionals, policy-makers, consumers, and the general public in Morocco. This table may also be useful for other countries in North Africa with similar food consumption habits or Moroccan immigrant populations in other countries.

2. Methods

2.1. Compilation process and data sources

The approach used in this study was the indirect method based on pre-existing data from scientific literature. Our data were compiled according to international standards, guidelines for food composition data, and the compilation process set by the FAO/INFOODS. The following FAO/INFOODS tools were used: Guidelines for checking food composition data prior to publication of a user table/ Database Version 1.0 (FAO/INFOODS, 2012), FAO/ INFOODS compilation tool version 1.2.1 (FAO/INFOODS, 2011), and FAO/ INFOODS food component identifiers, called tagnames (FAO/INFOODS, 2014).

Our primary source was the revised local FCT published in 1984, and the analytical values reported on Moroccan foods (El Khayate, 1984). In order to evaluate if the information on food composition from this source is still valid, all values included in this table have been checked, and modifications have been applied when new analytical data were available in the Moroccan published and unpublished literature.

A range of composite dishes and prepared foods were included in this table, predominantly traditional recipes commonly consumed in Morocco. Before resorting to international sources of data, nutrient data of these recipes was derived from local sources or from data published by the Centre d'Information et de Recherche sur les Intolérances et l'Hygiène Alimentaires (CIRIHA database) in Brussels (CIRIHA (The Information and Research Centre for Food Intolerances and Hygiene), 2019) that contained information on the composition of traditional recipes frequently eaten by the Moroccan population living in Belgium. Nutrient values of recipes from this database were calculated by using the Becel institute nutrition software (BINS).

In order to obtain a more complete list of food items consumed in Morocco, literature searches were carried out using scientific literature, popular Moroccan cookbooks, and gray literature (unpublished sources). Data from national dietary surveys on food consumption of Moroccans were also used to complete and to determine foods consumed in Morocco (HCPM, 2015; MAM, 2007). The prioritization criteria in including foods were based on food consumption frequency, food description, and completeness, and consistency of data. Generally, the table was extended to include a food list representing the most frequently consumed foods in Morocco, which were grouped into 15 food groups. The nutrients contained in this FCT were selected for their importance in the field of nutritional epidemiology (Slimani et al., 2000).

Whenever this primary source of local analytical data was insufficient, values were borrowed from similar food items of FCTs in the region, more in particular the FCT of Tunisia (NINT, 2007) and the West African FCT (2012) (FAO, 2012). Finally, the French FCT ANSES-Ciqual 2017 (FAFEOHS, 2017), the FCT of the United Kingdom (McCance and Widdowson's tables) (PHE, 2015), and the United States Department of Agriculture (USDA) Food Composition Database (USDA, 2016) were used to compile this FCT and to reduce the amount of missing information. Where food composition values from these databases were used, preference was given to data (1) where the databases are from the region, (2) where the food name (food description) was similar to that used in Morocco, (3) where the database provides detailed information on the sample, preparation, and methods of analysis.

2.2. Food descriptions and codes

Food names were chosen to describe the food items as appropriately as possible. We used generic names (e.g., egg, bread), and additional specifications/descriptors such as type (e.g., white), processing (e.g., roasted, boiled), physical state (e.g., raw), parts (e.g., seed), when appropriate. Most of the composite dishes are given by their Moroccan names. A unique five digits code was assigned to each food item. The code has been assigned in such a way that the first two digits represent a food group, and the last three digits represent a food item and its specifications.

2.3. Definition and expression of components

List of components with corresponding INFOODS tagnames, units, analytical/determination methods as provided by the sources are given in supplementary material- 2. This FCT includes information on 38 components. All food composition values are expressed per 100 g edible portion on a fresh weight basis of the food (i.e., meat without bone, apple without a core, etc.). INFOODS Tagnames were used to describe the components. The zero value in the table indicates that the content of the component is considered to be zero. The term trace (Tr) suggests that only a trace of the nutrient in question was known to be present. For missing data, the space of the value remains empty.

2.4. Documentation and quality considerations

Documentation at value level: for each nutrient value, the data sources are given with the respective reference ID in supplementary material- 3.

Data quality of this FCT was checked according to relevant sections of the FAO/INFOODS Guidelines on Checking Food Composition Data prior to the Publication of a User Database/Table (FAO/INFOODS, 2012). Data checks and quality controls were performed for clusters of components whenever possible, in order to detect outliers, typing errors, unreasonable values, etc. The following are some examples of checks that were applied at component level: sum of SFA + MUFA + PUFA is lower than total fat; energy kcal should be

Table 1
Nutrient composition, list of food groups and number of food items in each group present in the last FCT (1984) and the current updated FCT (2019).

	The FCT (1984)	The updated FCT (2019)	Differences/ increasing in n (%)
Components	**20**	**38**	18 (47.3)
Food groups	**11**	**15**	4 (26.6)
Cereals and their products	28	109	81 (74.3)
Starchy roots, tubers and their products	–	13	13 (100)
Nuts, seeds and their products	–	37	37 (100)
Vegetables and their products	16	39	23 (58.9)
Legumes and their products	5	12	7 (58.3)
Fruits and their products	16	29	13 (44.8)
Condiments and sauces	–	25	25 (100)
Fat and oils	2	12	10 (83.3)
Dairy products	8	45	37 (82.2)
Eggs and their products	1	5	4 (80.0)
Sugars, sweeteners and syrup	3	18	15 (83.3)
Beverages (alcoholic and nonalcoholic)	23	81	58 (71.6)
Meat and poultry and their products	4	104	100 (96.1)
Fish and their products	16	31	15 (48.3)
Prepared foods	–	27	27 (100)
Total food items	**122**	**587**	**465 (79.2)**

comparable to energy calculated from macronutrients, etc. About 2.5 % of component values were corrected based on this these quality controls.

To assess the quality of data on nutrient concentration, the percentage of analytical data for each component was calculated based on the total of reported analytical values included in this FCT.

3. Results

The present version of the Moroccan FCT includes information on 38 components for 587 food items, of which 465 (79.2 %) are extra to the original FCT. Food groups added in this updated FCT include starchy roots, tubers, and their products; nuts, seeds, and their products; condiments and sauces; and prepared foods. Food groups in which a large number of items have been added are cereals and their products, meat and poultry and their products, and dairy products. In addition, three hundred and twenty-seven cooked and/or processed foods were included in this FCT. Table 1 shows a comparison between the last FCT (1984) and the currently updated FCT (2019) in terms of a number of components, a list of food groups, and the number of food items in each group.

About 7 % of nutritional values included in this FCT were derived from Moroccan data sources and about 93 % from foreign sources (Supplementary material- 3).

Table 2 shows food composition items included in this 2019 FCT, units, and percentage of reported analytical data. The percentage of reported analytical values included in this FCT ranged from 47 % for calcium to 78 % for folates.

The updated version of the Moroccan FCT (2019) is provided in Excel format as supplementary material- 1, and available to the public on http://ww2.fmp-usmba.ac.ma/.

Table 2
Components, units, and percentage of reported analytical data, Moroccan FCT (2019).

Component	Unit	Borrowed analytical data (%)
Energy	kcal and KJ	
Water	g	59.7
Protein, total	g	53.9
Fat, total	g	53.9
Carbohydrate	g	
Fiber, total dietary	g	56.6
Sugar, total	g	70.6
Starch, total	g	64.6
Saturated fatty acids	g	52.2
Monounsaturated fatty acids	g	52.2
Polyunsaturated fatty acids	g	52.2
Cholesterol	g	49.8
Sodium	mg	49.1
Potassium	mg	50.1
Calcium	mg	47.9
Magnesium	mg	51.7
Phosphorus	mg	49.1
Iron	mg	48.8
Zinc	mg	51.5
Copper	mg	51.0
Manganese	mg	55.2
Selenium	mcg	54.2
Vitamin A, RAE[a]	mcg	58.5
Retinol	mcg	65.0
Beta-carotene	mcg	49.4
Vitamin D	mcg	60.4
Vitamin K	mcg	55.9
Vitamin E	mg	55.1
Vitamin C	mg	55.8
Thiamine	mg	55.1
Riboflavin	mg	55.6
Niacin	mg	55.1
Pantothenic acid	mg	56.3
Vitamin B6	mg	57.1
Folates	mcg	78.6
Vitamin B12	mcg	52.7

[a] RAE: retinol activity equivalents.

4. Discussion

The main objective of this work was to update the latest available version of the Moroccan FCTs published in 1984, by adding dietary data relevant to the Moroccan population.

Compared to the 1984 Moroccan FCT, this updated version was a significant improvement in terms of completeness and accuracy of the data on the composition of foods commonly consumed in Morocco, the number of food items (587 versus 122) and nutrient components include (38 versus 20). In addition, also the compilation process was importantly improved by adhering to international guidelines, the use of international tools, and by including more details on components and data documentation. In addition, data from this FCT includes a considerable percentage of reported analytical data. However, it may be slightly less reliable compared to some other FCTs in the African region, which are mainly based on analytical data, such as the Kenya FCT- 2018 (FAO/Government of Kenya, 2018) and the South African FCTs- 2017 (SAFOODS, 2017).

In this work, the approach chosen to update the Moroccan FCT was the indirect method. Generally, the common methods used to compile or update the food composition databases are direct, indirect or a

combination of methods (Greenfield and Southgate, 2003; Lopes et al., 2015). The direct method based on chemical analytical data is the preferred method to obtain highly reliable data that reflects the accurate component content in a portion of food (Greenfield and Southgate, 2003). However, this method requires significant financial resources and skilled laboratory investigators and is time-consuming (Marconi et al., 2018; Koréissi-Dembélé et al., 2017). At the moment this method is practically difficult to be conducted in Morocco due to lack of resources. The indirect method, that consists pre-existing data on foods and nutrients of interest taken from published literature or unpublished laboratory reports (Greenfield and Southgate, 2003), is considered the best alternative in our context. However, this method has less control over the quality of the data, and great care must be taken in their assessment for inclusion in the database.

Generally, minimizing the number of imputed and calculated values, included in the database, increases the reliability of the food composition data. Therefore, in our context, and in order to improve the quality of our database and to ensure that the nutrient contents of the foods are appropriate for Morocco, efforts were made to include as many analytical data as possible from Moroccan sources. Unfortunately, our local data was rather incomplete and needed to be extended with additional data. In addition, details of the chemical analysis, sample, and method of preparation were lacking in most of the local sources. Food composition information derived from unreliable sources (e.g., industry) and/or obtained through unverified laboratory methods may produce biased and misleading information on food composition and as such, increase confusion while leading to unreliable nutritional recommendations (Buttriss and Benelam, 2010). Therefore, further completion of the FCT with other databases (e.g. from neighboring regions/countries) is indispensable.

The FCT presented in this paper was based, for a large part, on international databases. For example, the Tunisian FCT, that contains a wide range of similar foods as those consumed in Morocco, was chosen as a starting point for international data collection. Respecting the standard procedure of selecting primarily the tables from the region (e.g., neighboring countries) with foods that are most similar to the Moroccan foods, the West African FCT was selected as our second foreign source. Other international databases were used when no information was found in Moroccan, Tunisian or West African FCTs. These other international sources of data (ANSES-CIQUAL 2017, the M &W 2015 and the USDA, 2016) were chosen because they are extensive and reliable databases, and they are regularly updated. Similar approaches were used by several investigators in the world to complete their food composition databases (Gnagnarella et al., 2004; Shai et al., 2003; Machackova et al., 2010; Merchant et al., 2005; University of Helsinki, 2011; University of Dhaka, 2013; Arab Center for Nutrition, 2011). However, this approach has several disadvantages, and the quality of data should be taken with caution. For instance, the nutrient content of food items included in the international databases may differ from those grown in Morocco as a result of differences in the content of nutrients and other substances in the soil, differences in exposure to the sun, weather conditions, agricultural practices, and for different varieties of plants and animals (Marconi et al., 2018; Lupiañez-Barbero et al., 2018).

In addition, food component variability from country to country and errors in matching similar foods or in the identification of the exact dish in other sources may lead to over- or underestimation of nutrients (Puwastien, 2002). Also, given that there are differences in fortification guidelines between countries, caution is needed when borrowing food composition values from other countries. In this FCT, care was taken not to select fortified foods from international FCTs.

Some nutrient values borrowed from the Tunisian FCT and the CIRIHA database were estimated by recipe calculations. The calculation is a valid method to determine the nutrient values of foods, but can lead to errors caused by inadequate ingredient data (Machackova et al., 2018). In addition, there are differences between calculated and direct chemical analyses values, due to different types of cooking equipment, the surface area of food contact exposure, length and temperature of cooking, and volume of product on the yield factors, retention factors, and water/fat, loss/gain factors (Rand et al., 1991); Parpinel et al., 2000; Reinivuo et al., 2009). This limitation may be a source of some errors in nutrient estimation. In the Tunisian FCT, where values are calculated, appropriate yield factors were applied to reflect the effects of food preparation and weight change in foods or recipes. However, information on nutrient retention factors is lacking in this FCT.

The lack of detailed analytical data, definitions of components, and data documentation in certain sources used in this work (e.g., Moroccan FCT- 1984), present the most important limitations of this FCT. Almost 3.8 % of the food component values in this FCT, mainly derived from the Moroccan FCT- 1984, could not be assessed for data quality due to insufficient information provided by the source. The data derived from this source should be taken with caution. The same issue has been reported in some FCTs for African countries such as West African FCT- 2012 (FAO, 2012), Mozambique FCT- 2011 (University of Helsinki, 2011), etc.

As in many FCTs borrowing data from various sources, the component definitions given in this FCT may slightly vary according to the data source. For example, the total carbohydrates contents might be calculated by inclusion or exclusion of dietary fiber.

The other limitation in this FCT is the existence of a large number of missing values. The assignment of zeros to these missing values in the analyses leads to an underestimation of daily nutrient intakes. The impact of missing values on the underestimation depends on its proportion and the frequency of consumption of foods with incomplete data (Charrondiere et al., 2002).

An important strength of this updated Moroccan FCT is the standard operating procedures that were strictly followed and the important contribution of world leaders in this area of compiling national FCTs. The large number of food components included as well as the exhaustive list of foods and dishes are two important features that contribute to the usefulness and quality of this updated FCT.

5. Conclusion

The FCT presented in this paper provides, for the first time since 1984, information on relevant food components of the main food items consumed in Morocco. Despite some limitations, it is a useful tool for assessing Moroccan' nutrient intakes, accessible to the public, and it should be continuously updated. Finally, we hope that this work will be considered as a first step for producing future releases with more chemical analysis, a high number of food items, and high-quality composition data. Indeed, more research and more collaborative work are necessary to achieve this objective.

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CRediT authorship contribution statement

Mohamed Khalis: Conceptualization, Methodology, Formal analysis, Writing - original draft. **Vanessa Garcia-Larsen:** Conceptualization, Methodology, Validation, Writing - review & editing. **Hafida Charaka:** Data curation, Writing - review & editing. **Meimouna Mint Sidi Deoula:** Data curation, Writing - review & editing. **Khaoula El Kinany:** Data curation, Writing - review & editing. **Abdelilah Benslimane:** Data curation, Writing - review & editing. **Barbara Charbotel:** Writing - review & editing. **Amr S. Soliman:** Writing - review & editing. **Inge Huybrechts:** Validation, Writing - review & editing. **Ghada A. Soliman:** Validation, Writing - review & editing. **Nadia Slimani:** Validation, Writing - review & editing. **Karima**

El Rhazi: Conceptualization, Methodology, Validation, Investigation, Writing - review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no competing interests.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jfca.2019.103397.

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