Journal of Food Composition and Analysis 102 (2021) 104047

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

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

Original Research Article

Development of an Arabic food composition database for use in an Arabic online dietary assessment tool (myfood24)

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ARTICLE INFO

Keywords:
Food composition table
Food composition database
Myfood24
Composite food
Middle East
Arabic
Dietary assessment tool

ABSTRACT

A comprehensive food composition database (FCDB) is essential for assessing dietary intake of nutrients. However, currently available food composition data for Gulf Cooperation Council countries (GCC) is limited. The aim was to develop an Arabic FCDB of foods commonly available in the GCC (initial focus on Saudi Arabia and Kuwait), which will be integrated into an Arabic version of an online dietary assessment tool, myfood24. The Arabic FCDB was built using a standardized approach identifying currently available foods from existing food composition tables (FCTs), research articles, back-of-pack (BOP) nutrient labels on food products, with additional generic food items from the UK Composition of Foods Integrated Database (CoFID). The development of the FCDB used a 6-step approach: food identification, cleaning, mapping, translation, allocating portion sizes, and quality checking. The database includes a total of 2016 food items, 30 % of which have standard portion size images in addition to other options for portion size estimation. The database and myfood24 have been translated into Arabic to be suitable for Arabic users. These tools will help to assess dietary intake for 51 million people in the GCC. Future work will cover more foods from other Middle Eastern countries to serve over 400 million Arabic speakers in the region.

1. Introduction

Accurate food composition databases support the quantification of nutrients consumed to evaluate nutritional intakes (Foster et al., 2014). Food Composition Tables (FCTs) for Middle Eastern foods are limited in terms of foods and nutrients (Al-Faris, 2017; Musayqar, 2006; Pellet and Shadarevian, 1970; Sawaya et al., 1998). Researchers in Gulf Cooperation Council (GCC) countries have used food composition databases (FCDB) from non-representative populations/countries including the USDA (Al-Daghri et al., 2013; Alkazemi Dalal Usamah, 2019) but there is a need to develop a representative food database for these countries. An FCDB should include a wide range of local and commonly consumed foods with a comprehensive nutrient profile (Greenfield and Southgate, 2003). While the analysis of foods in a laboratory is costly and time-consuming, the use of existing nutritional data is cost-effective to develop an FCDB for countries with limited resources and data (Greenfield and Southgate, 2003).

Traditionally, interviewer-led, paper-based food frequency questionnaires (FFQ), food diaries, dietary records, and 24 -h dietary recalls were used to collect food intakes (Carter et al., 2016; Thompson and Subar, 2017). However, these methods are becoming outdated with limitations: they are time-consuming and burdensome for both participants and interviewers and experience potential under-reporting, measurement error and expense due to coding and processing requirements (Conrad et al., 2018; Thompson and Subar, 2017; Touvier et al., 2010). While large population-based studies have often favoured FFQs

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https://doi.org/10.1016/j.jfca.2021.104047
Received 23 December 2020; Received in revised form 10 June 2021; Accepted 15 June 2021
Available online 17 June 2021

(Thompson et al., 2015), 24 -h dietary recalls may be more accurate (Freedman et al., 2014). Furthermore, new web-based systems offer advantages over traditional time-consuming techniques, allowing for self-administered recalls (Cade, 2017; Eldridge et al., 2018; Foster et al., 2014; Zenun Franco et al., 2018), without compromising on accuracy (Conrad et al., 2018; Koch et al., 2020; Park et al., 2018; Wark et al., 2018a).

The online dietary assessment tool, myfood24, is a validated tool, initially developed for the UK population (Albar et al., 2016; Carter et al., 2015; Wark et al., 2018b). The system is supported by a comprehensive UK FCDB (~60k food items) which facilitates its use as a self-reported 24 -h dietary recall or dietary record (Carter et al., 2016). The myfood24 system has been adapted to different languages in terms of food database and its functions and layout and there are currently Danish, Norwegian, French and German versions. There are more than 422 million Arabic speakers in the Middle East region (Boudad et al., 2018), yet there is no Arabic web-based dietary assessment tool incorporating common foods for this population. Therefore, the aim was to develop an FCDB of GCC foods, with a focus on Saudi Arabia and Kuwait, to be incorporated into an Arabic version of myfood24. This paper illustrates the methods and techniques used to develop the FCDB, which has been included in an Arabic version of myfood24.

2. Materials and methods

The development of the Arabic FCDB was undertaken in the following steps: food identification, cleaning and processing of data, mapping procedure and quality checking. Then, additional steps were undertaken to enable the inclusion of the database in the Arabic myfood24 as seen in Fig. 1.

2.1. Identification of foods for inclusion in the food composition database

A literature search of Arabic and Middle Eastern foods and composition data was conducted using: Medline, Web of Science, Saudi Digital Library (SDL), and Google Scholar using different combinations of the keywords: "Arabic/Middle Eastern food composition table/database". Searching involved both electronic and printed research articles and existing FCTs. Most of the academic literature was freely available online, whereas FCTs were hard copies obtained upon request.

Branded food products with back-of-pack (BOP) nutrition labels were identified for foods frequently reported in national studies (Adam et al., 2014; Almajwal et al., 2018; Alsufiani et al., 2015; Gosadi et al., 2017) and were available in local food stores. For example, dairy products were frequently reported in national surveys; and we searched for these food products on the websites and in-store of local retailers. To ensure a comprehensive database of foods and complete nutritional information, we included generic foods (e.g., fruits, vegetables, spices, etc.) from the UK food database (Public Health England, 2019).

The following sources were identified: (1) three existing FCTs ("Kuwaiti's Composite Food Table" (Sawaya et al., 1998); "Food Composition Tables for Arab Gulf Countries" (Musayqar, 2006) and "Food Composition for Use in the Middle East" (Pellet and Shadarevian, 1970); (2) food composition from 9 published research articles (Al Jasser, 2015; Al-Bahrany, 2002; Al-Faris, 2017; Al-Kanhal et al., 1998, 1999; Assirey, 2015; Dashti et al., 2004, 2003a; Dashti et al., 2003b, 2001); (3) back-of-pack (BOP) label information; (4) generic food items from the UK Composition of Foods Integrated Dataset (CoFID) (Public Health England, 2019).

Food identification was based on food names, synonyms, descriptions, and ingredients known to the target countries by local bilingual researchers (authors AB & SK). We included foods relevant to the local population by including core commonly consumed foods (e.g., dairy products, grain products, meats and poultry), composite foods and other less commonly consumed items (e.g., regional types of fruit, vegetables, seafood, etc).

2.2. Cleaning and processing of the data

The creation of the database followed the procedure and standards for the creation of FCDB in myfood24, and nutrients were defined in accordance with the requirements of myfood24 which is based on the UK database (CoFID). Identified data were extracted from the original identified sources into an Excel sheet for processing as follows: (1) Removing duplicate foods with identical ingredients, cooking methods, and macronutrients. Where duplicates were identified, foods with the most complete nutrient analysis were included (53 duplicate food items were removed). If differences in ingredients or method of cooking were found, both food items were kept (e.g., Dulmah and stuffed grape leaves are similar but differ in some ingredients; Kofta (meatball) was included as both grilled and fried). (2) Reformatting of units for some nutrients from existing tables/literature was undertaken to match the formats in myfood24, e.g., vitamin D was converted from IU to μg. Also, some BOP values were presented by portion size rather than per 100 mL or 100 g, so values per 100 mL or 100 g were generated. (3) Missing values for some nutrients were calculated from other existing nutrients. Total nitrogen was calculated by dividing protein content from the original source by the nitrogen conversion factor (6.25) (Greenfield and Southgate, 2003). Where carbohydrate was missing, it was calculated by difference, subtracting the calories obtained from protein (4 kcal/g) and fat (9 kcal/g) from the total calories. The calories provided by carbohydrate were then divided by 4 to obtain a value in grams. For the fruit, dates, a staple item in the Middle East, values of carbohydrate and calories were missing from local FCT. Carbohydrates were estimated from the sugar values for dates obtained from an existing FCT (Greenfield and Southgate, 2003), then total calories were calculated through the myfood24 system.

The definitions of nutrients in the current work are based on those stated in the UK FCDB (CoFID) (Pinchen et al., 2021). For example, carbohydrate values were based on values for total carbohydrate from the sum of analysed values for components of available carbohydrates not including fibre. However, in the case of missing data, they were calculated as explained above for carbohydrate and energy.

Initial cleaning processes were applied to the 429 food items from the existing FCTs, publications and BOP, while generic food items from the UK CoFID were already in the required format and of appropriate quality.

2.3. Mapping procedure to generate nutrient values

The mapping process was based on the approach used to create the UK food table underlying myfood24 (Carter et al., 2016). The purpose was to assign available nutrients to the foods in the database from existing published FCT/FCDB, and to generate values for missing nutrients (mostly micronutrients) by matching them to similar items from the UK FCDB (CoFID) (Public Health England, 2019) using the myfood24 system.

Mapping was carried out using Microsoft Access. The mapping process generated nutrient values for all nutrients, including those already available from the original sources, which allowed us to ensure that our matching for nutrients was similar to the original. Mapping involved matching foods, and the matching criteria were compliant with the FAO/INFOODS guidelines for food matching (FAO/INFOODS, 2012b). During the mapping process, the programme used (Carter et al., 2015) suggested a range of generic food items (available from the built-in food database (CoFID)), and the researchers were able to select the most appropriate match. We ensured the results from mapping provided values close to (no more than 10 % difference) the original source values for water content, total calories and macronutrients (grams of carbohydrate, protein and fat).

In order to calculate missing nutrients for composite foods using the mapping technique, we used standard recipes from local recipe sources (Al-Qassar, 2012, 2016; AL-Turky, 2013; Musali et al., 1990; Sawaya

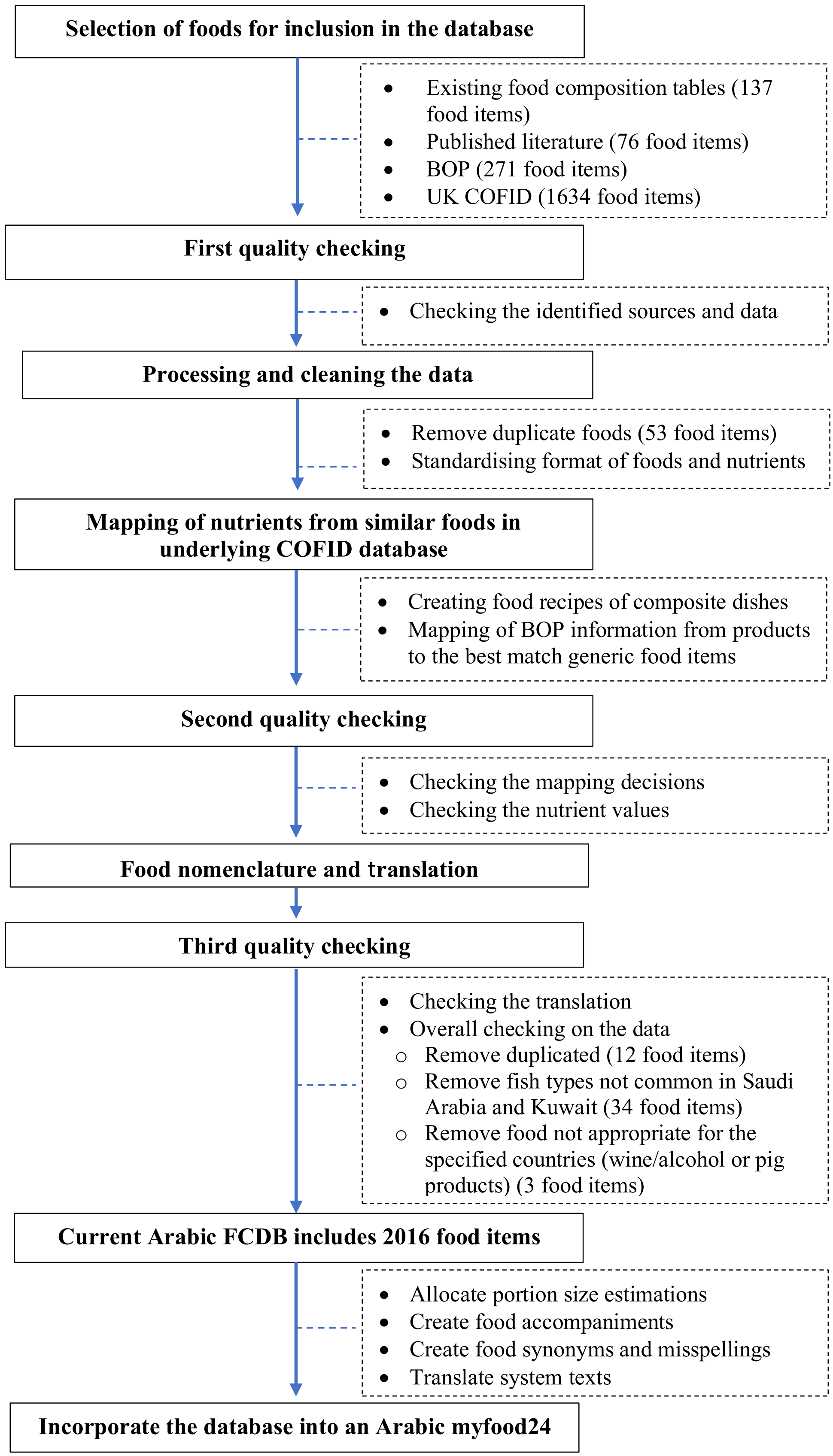

Fig. 1. A flow chart of developing the Arabic FCDB.

et al., 1998). To allocate nutrient values where these were missing, we mapped recipes to cooked ingredients since the available nutrient data for the composite foods we identified were for cooked foods. In order to get accurate quantities of cooked ingredients, we applied yield factors from "*McCance and Widdowson's The Composition of Foods*" (Finglas et al., 2015) from the raw ingredients (Finglas et al., 2015; Rand et al., 1991). Water, as an ingredient had volumes adjusted to take into account the evaporation and/or absorption while cooking (Bognár, 2002; Greenfield and Southgate, 2003). Each ingredient was allocated a percentage contribution to the total recipe to enable the generation of missing nutrient values using the myfood24 system. To illustrate an example, Marag Laham is a composite food identified from the searched FCT, which had some missing nutrients. Thus, to generate values for these missing nutrients, we obtained the recipe (raw ingredients in grams). However, to ensure matching with the existing nutrient values from the identified FCT which were for the cooked item, with the values resulting from the mapping process, we mapped to cooked ingredients as seen in Fig. 2. Since we mapped to cooked items, the water content was already taken into account with the tomato juice/sauce.

In circumstances where a particular ingredient was not available within the existing UK myfood24 FCDB, a nearest sensible alternative item from the same food group similar in terms of nutrient content was selected (e.g. Molokhiya, a local green leafy vegetable, was mapped to curly Kale). For some food items, we matched a combination of more than one item within the same food group to obtain the missing values (e.g. Akawi cheese was mapped to 70 % Mozzarella and 30 % Halloumi cheeses).

Branded products with declared BOP nutrient information for energy, carbohydrate, sugar, protein, fat, saturated fat, trans-fat, and sodium were matched with similar generic food items to obtain a comprehensive set of nutrient values. For example, BOP values from a branded milk product were mapped to a milk item within the UK FCDB using the myfood24 system. Table 1 highlights some of the mapping decisions undertaken.

2.4. Food nomenclature and translation

The Arabic FCDB was initially developed in English and then translated into Arabic. The translation was done in duplicate by two bilingual researchers (AB, SK), independently. All foods identified were given a food name, a detailed description (e.g., source, processing type, fat content, etc.) and a unique numerical food identifier for inclusion in the database.

2.5. The Arabic myfood24 system

The myfood24 system was established in its original English version for the UK population in 2015 (Carter et al., 2015) with the option to create additional country-/language-specific versions of the tool. In order to create the Arabic version, an appropriate FCDB and some additional features such as portion size estimation support and food

Table 1
Examples of mapping decisions for local foods and recipes to generate complete nutritional information.

Food Item	Closest matched foods
Tannouri bread	100 % nan bread
Molokhiya	100 % curly Kale
Marag bamiah	44 % Okra boiled in unsalted water, 9% onion fried in sunflower oil, 21 % tomato puree, 1% Allspice ground, 1% tamarind pulp, 16 % lean stewed lamb, 2% reduced fat tomato base, 1% puree garlic and 1% salt, 4% water
Makbos/Kabsa laham	63 % basmati rice boiled, 5% chickpeas boiled, 3% raisin, 1% ground allspice, 19 % grilled lamb chops, 8% sunflower oil &1% salt
Balila	80 % canned chickpeas, 1% cumin, 3% vinegar, 1% salt and 15 % distilled water
Akawi cheese	70 % Mozzarella and 30 % Halloumi cheeses
Labnah	10 % Yogurt powder and 90 % Greek yogurt

accompaniments were developed, which are described in this section. The next step involved translating the whole database alongside the translation of the original text within myfood24, including the administration side where projects are set up and the instructions for using the food diary, into Arabic. The entire Arabic files were then returned to the myfood24 developer team for the construction of the Arabic version of myfood24.

2.5.1. Portion size estimations

We used multiple options for portion size estimations: portion size images, standard household measurements (in cups and spoons), serving sizes of products from BOP labels, and average portion sizes. We used 50 food images (each with 7 different portion sizes) from the "*Young Person's Food Atlas*" (Foster et al., 2010) within the current database. These ranges of portions had previously been shown to cover all adult and adolescent portion sizes for the UK (Carter et al., 2015). The previous UK food atlas (Nelson et al., 1997) has been used in the Abu Dhabi Photographic Atlas of Food Portions (Al Marzooqi et al., 2015) and other studies of Middle Eastern populations (Ahmed et al., 2012; Dehghan et al., 2005), suggesting that portion sizes are likely to be similar. Food portion images for a few additional items relevant to foods in the current database were photographed (Fig. 3) following training by a food photography specialist based on standard guidelines (Abu Dhabi Food Control Authority et al., 2014; Foster et al., 2010). The weights of the portion sizes for these items were based on the Abu Dhabi Photographic Atlas of Food Portions (Abu Dhabi Food Control Authority et al., 2014). Some images were used multiple times by allocating them to food items similar in terms of appearance and/or composition (Al Marzooqi et al., 2015; Carter et al., 2016). For example, white rice portion images were assigned to all rice dishes; stuffed grape leaves images were assigned to dolma and stuffed cabbage.

2.5.2. Food accompaniments

Prompting for any missing food accompaniments where a food item

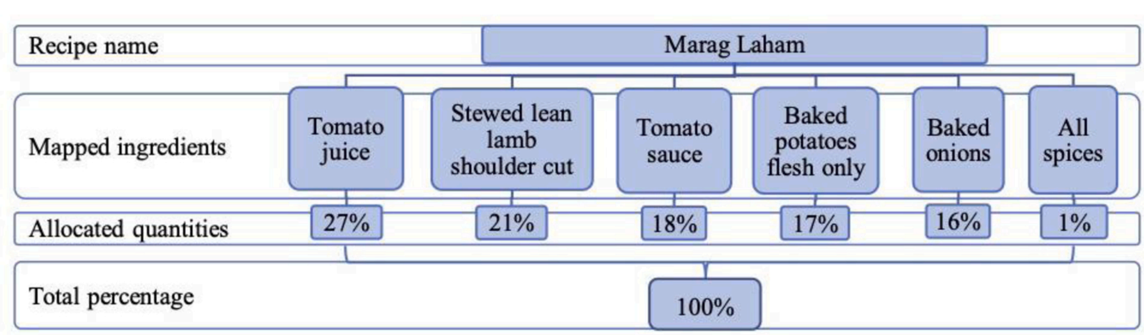

Fig. 2. Example of mapping for the composite food "Marag Laham" with the allocated percentages of each ingredient.

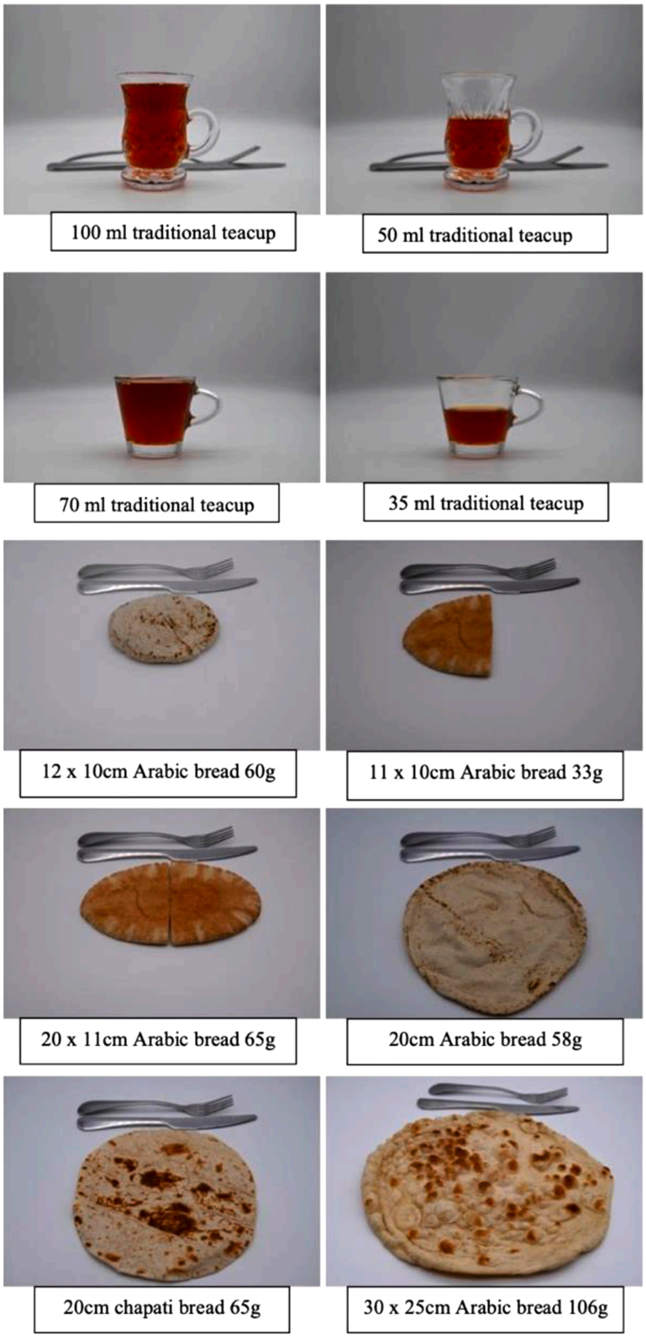

Fig. 3. Examples of food portion images created based on local foods.

is commonly consumed with another food is one of the features of myfood24. Thus, we created a list of food accompaniments as seen in Table 2. For example, if dates were selected, prompts to add Arabic coffee, yogurt and laban would occur automatically.

Table 2
Examples of food accompaniments.

Food logged in as being consumed	Common food accompaniment prompts
Rice	Stewed dishes (e.g., stewed meats, vegetables and stuffed vegetables)
Bread	Peanut butter and jam, egg (e.g., omelette, boiled), and humus
Coffee and tea	Milk and sugar
Dates	Arabic coffee, yogurt and laban (kefir)

EANs (European Article Numbers) were used as unique identifiers in the myfood24 database to uniquely identify foods and to prevent over-stamping (i.e. one item replacing another). The Arabic database was given a unique EAN range, specific to this regional database. This allows portions and accompaniment information to be linked to the correct foods.

2.5.3. *Food synonyms and misspellings and system translation*

To facilitate searching for foods within the myfood24, synonyms of food names based on different dialects existing in Kuwait and Saudi Arabia (e.g. rice called "aish عيش" and "ruz رز") were added. Also, we included potential misspellings (e.g. potential misspellings of the word rice like رز، أرز، ارز).

2.6. *Quality checking*

Quality checking procedures, compliant with FAO/INFOODS guidelines on checking data for inclusion in FCDB (FAO/INFOODS, 2012a), were applied throughout the process. Here we present the checking procedures applied in three stages.

2.6.1. *First quality checking stage*

The first stage of quality checking was conducted on the identified sources and foods ensuring appropriateness and sufficiency of the data. For each source, data were extracted and documented in an Excel sheet originally designed by the myfood24 team. Data required for each food was the food name, synonyms, food descriptions, food category and nutrients. The extracted data were checked against the original source to ensure that values were combined and matched; and nutrients and values (units and denominators) had been included in the database correctly. Also, data were checked for any missing values requiring the generation of nutrients by mapping.

2.6.2. *Second quality checking stage*

The second stage of quality checking was conducted after the mapping procedure. This involved 1) checking the quantities and description of matched ingredients and decisions relating to volume changes with cooked foods (e.g. pasta); 2) Checking and confirming matched food selection for missing foods (e.g. Molokhiya); and 3) Checking all the nutrient values resulting from the mapping. This stage was carried out by a nutritionist (SB), an expert in food analysis (MR) and the local researchers. The local researchers independently calculated the recipes and mapped foods to generate complete nutrient information. Subsequently, results were checked with the nutritionist (SB), to ensure plausible nutrient values.

2.6.3. *Third quality checking stage*

The final stage was performed after the translation by the native researchers to ensure all translations (e.g., translation of food names, descriptions, components) were accurate. This stage also involved checking that the synonyms and misspellings were sufficient to cover any potential search terms within the Arabic myfood24 as well as checking the translations of portion size units, system text, prompts and user instructions.

3. Results

The Arabic FCDB is comprised of food items consumed in Saudi Arabia and Kuwait. The database includes in total, 2016 food items with their macronutrient and micronutrient data (120 nutrients available for all foods). A full list of nutrients can be seen in Table A.1 in the Supplementary data. All data included are in either 100 g or 100 mL edible proportion. About 30 % of the food items in the Arabic FCDB were assigned portion size images in addition to standard household measurements or serving sizes from BOP labels.

As shown in Fig. 4, the majority, 79 % (n = 1585), of the data in the

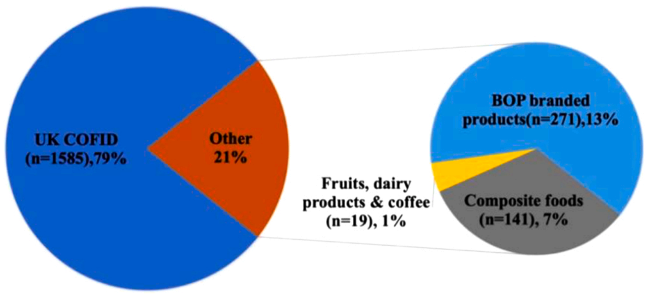

Fig. 4. Sources of data for the new FCDB.

Arabic FCDB, were generic items from the UK CoFID. The large percentage of foods included from the UK database is due to the addition of generic food items such as meats, poultry, fruits, and vegetables in addition to some commercial food items (e.g. nuts, biscuits, and puddings) and condiments (e.g. spices, dressings, and sauces). These foods were chosen from the CoFID since that database already has a complete set of nutrient information and whilst there may be some regional variations, we wanted to include quality assessed standard information. Foods with BOP label information for local and regional branded products in Saudi Arabia and Kuwait comprised 13 % (n = 271) of the food items. Food items from existing FCTs and research articles contributed 8% (n = 160) of the final database items. Out of these 160 items, 141 were composite foods and 19 items were local fruits (mostly dates), local dairy products and Arabic coffee drinks.

Meat-based composite dishes represented the majority of the food items obtained from the existing FCTs and research publications followed by desserts and cereal-based foods, while most of the fruits included were dates (e.g. Ajwa, Sukkari, Khodari, Suqaey). The highest number of branded products included were dairy products. The majority of the branded products were from the largest dairy, bakery and confectionery and fast-food producers in the region. Tables A.2 in the Supplementary Materials shows the number and source of food items in the Arabic myfood24 FCDB.

In total, as seen in Fig. 5, the whole database included 14 % of items from both meat products and dishes (n = 286) and vegetables and vegetable-based dishes (n = 278); 11 % of items were cereal products and associated dishes (n = 230); 9% sweet-tasting foods (e.g., desserts and chocolate) (n = 187); and 8% were fruits (n = 171), seafood (n = 166), and dairy products (n = 166). There were only 5% poultry products and associated dishes (n = 99), 5% beverages (n = 93), and 3% bean-based dishes (n = 68), while 13 % come from miscellaneous foods including spices (n = 81), savoury snacks (n = 53), sauces (n = 52), ready-to-eat products (n = 39) and oils (n = 24)

Table 3 displays selected nutritional information for some of the most commonly consumed foods. It can be seen from the examples in the table that the highest source of energy/100 g comes from high sugar foods like Basbousah (a dessert), dates, and cakes. The composite savoury dishes illustrated are mostly eaten for lunch/dinner (e.g. Marag Laham, Margook and Mandi) and are higher in protein and also sodium. Coffee and dairy products, mainly milk and laban, are typically consumed daily. These items provide the lowest energy.

Sources of included data were scientific articles, existing regional FCTs, UK FCDB and BOP food labels. Some missing data was found in the national and regional sources. Nutrients to replace this missing data were estimated through the mapping procedure using the UK database. The format of the data included a description, definition of components, units and denominator, in accordance with the UK database (CoFID) included in myfood24, which we used for mapping and matching food items to complete missing values.

Results of the quality checking identified differences in the values of some micronutrients (e.g. sodium, potassium, magnesium, phosphorus) as a result of the mapping when compared with values reported in the identified sources for some composite dishes. Since the availability of nutrient values was variable or missing from the local sources, we included values from the UK database through the mapping procedure to ensure a consistent and complete set of nutrient value data. For food where a BOP food label was available, we matched the values of calories and macronutrients from the label to matched items within the UK database, which resulted in similar matched values. During the final quality checking, we identified and removed 12 duplicate foods and 3 food items that included wine in their description (not suitable for the population of this version of the FCDB). Also with a further search during translation, 34 types of fish unavailable locally were removed.

4. Discussion

This work describes the creation of an Arabic FCDB containing 2016 foods and its integration into the online dietary assessment tool, myfood24, producing a unique Arabic online dietary assessment tool.

Traditionally, creating an FCDB uses laboratory analysis providing high quality, reliable data, however, this process is costly and time-consuming. Furthermore, analysing a wide range of food items and composite dishes may not be possible (Marconi et al., 2018), and local

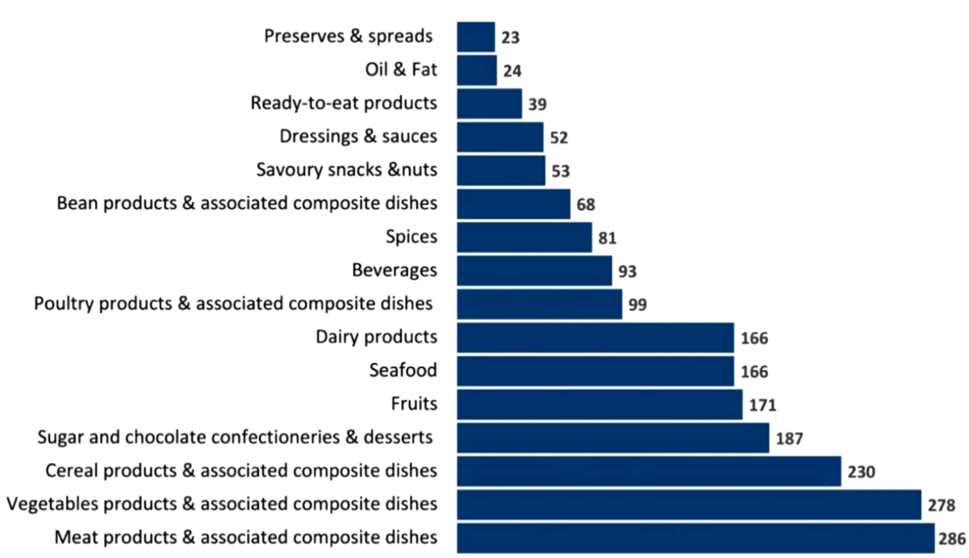

Fig. 5. Total number of foods included in the Arabic FCDB.

Table 3
Examples of the nutritional composition of chosen Middle Eastern foods included in the database.

Food name	Nutrients/100g											
	Water (g)	Energy (kJ)	Protein (g)	Total fat (g)	CHO[a] (g)	Fibre (AOAC)[b] (g)	Vitamin C (mg)	Vitamin E (mg)	Vitamin B12 (μg)	Calcium (mg)	Sodium (mg)	Iron (mg)
Composite foods												
Marag laham (مرق لحم	82.2	338	6.4	3.7	5.4	0.8	3.1	1.0	0.6	30	126	0.8
Margook (مرقوق)	75.9	422	5.1	2.8	12.9	1.5	2.4	0.3	0.4	22	90	1.0
Mandi rice & chicken (رز مندي بالدجاج)	56.6	556	8.2	4.6	15.4	0.4	0	0.5	0.0*	11	22	0.2
Basbousah (بسبوسة)	22.5	1401	3.9	6.9	64.4	1.4	0	1.0	0	17	7	0.9
Fruits (dates) and Arabic coffee drinks												
Sukkari date)تمر سكري(	14.2	1394	2.7	0.4	79.7	0	0	0	0	38	8	1.1
Coffee husk (قهوة قشر)	98.8	8	0.2	0	0.3	0	0	0.0*	0	2	0.0*	0.0*
BOP food products												
Laban full fat (لبن كامل الدسم)	88.1	251	3	3.3	4.7	0	0.6	0.5	0.1	120	48	0.1
Milk long life (ليب طويل الاجل)	87.6	259	3.2	3.2	5.4	0	2	0.0*	0.9	120	42	0.0*
Chocolate cake (كيك بالشوكولاته)	17.6	1644	6.5	18.5	49.4	1.6	0	0.6	0.5	51	430	1.2

* Trace values.
[a] Carbohydrate.
[b] "AOAC determinations include resistant starch and lignin in the estimation of total fibre, rather than only the non-starch polysaccharides" (Public Health England, 2019).

tables often present a limited number of nutrients (Merchant and Dehghan, 2006; Puwastien, 2002). In our work, we used existing data and generated missing data using a recipe calculation method and mapping to generic items with complete nutrient data using the UK CoFID. To ensure accurate values of nutrient content, we applied yield factors to raw ingredients in recipes since we mapped to cooked ingredients (Greenfield and Southgate, 2003; Reinivuo et al., 2009). Estimating nutrients based on recipe calculations have been done in European FCDBs within the European Food Information Resource (EuroFIR) (Reinivuo et al., 2009) and is approved as an alternative way of creating FCDB (Greenfield and Southgate, 2003; Machackova et al., 2018; Marconi et al., 2018; Rand et al., 1991). A comparison of recipe calculation with laboratory analysis, showed good agreement between the techniques for total calories and macronutrients (Vasilopoulou et al., 2003), however, discrepancies in micronutrient values were reported (Machackova et al., 2018; Marconi et al., 2018; Puwastien, 2002; Vasilopoulou et al., 2003). Differences in these nutrients may be due to natural regional differences in agricultural factors (e.g. crops breeding, soils, weather, and water) (Elobeid et al., 2014; Greenfield and Southgate, 2003; Marconi et al., 2018) or variations in food recipes and ingredients (particularly sodium values due to using sodium phosphates rather than sodium chloride or due to reformulation of salt in products) (Adam et al., 2014; Elobeid et al., 2014; Jacobson et al., 2013; Kapsokefalou et al., 2019; Machackova et al., 2018). Further differences may be due to methodological or procedural differences between databases (Cromwell et al., 1999; Marconi et al., 2018; Puwastien, 2002). These limitations can be generalised across all FCDBs. Developing an FCDB based on existing FCTs substituting missing data using similar foods or more comprehensive FCDBs/FCTs of other countries has been suggested as a method to use for enhancing food composition databases (Leclercq et al., 2001). Using this approach, allowed us to have a complete set of nutrients for each food item in our FCDB.

A representative FCDB in terms of the foods to be included is essential to obtain reliable information, especially, to assess dietary intakes for a specific population (Leclercq et al., 2001). The current work presents a national-level FCDB that contains composite dishes and branded products that are commonly consumed by the populations of Saudi Arabia and Kuwait. For example, rice dishes are the main food consumed in the region on a daily basis with red meat or chicken (Adam et al., 2014; Al-Mssallem, 2014). Wheat is also used as the main ingredient in traditional desserts (Al-Mssallem, 2014; Alfaris, 2018), however, dates remain the main dessert food commonly consumed with Laban (kefir) or Arabic coffee (Al-Mssallem, 2014). The majority of the BOP data in the Arabic FCDB was for dairy products, popular in Saudi Arabia and Kuwait (Adam et al., 2014, 2019; Alkazemi and Saleh, 2019). Dairy products in Saudi Arabia are produced locally (Adam et al., 2014), and are exported to Africa and other Middle Eastern countries (Almarai Company, 2017). Our database also includes a variety of products (e.g. snacks, confectionery and frozen foods) from one of the largest fast-food businesses in the Middle East with around 48 % and 41 % of its products in the Kuwaiti and Saudi Arabian markets, respectively (Mehta and Lulla, 2016). However, there are other common branded products missing in our database where BOP information was not available. This is a common problem as it is not possible to include all foods made available in the markets in an FCDB as new products are continually being produced (Leclercq et al., 2001). Thus, it will be important for researchers to build trust with food companies and retailers to support food surveys through providing access to new products and BOP nutritional information (Harrington et al., 2019; Kapsokefalou et al., 2019).

Branded products are updated regularly when regulations and formulation are changed (e.g. reductions in sugar, salt or fat) (Concina et al., 2016; Kapsokefalou et al., 2019), or new products are introduced (Black, 2017). This results in changes in nutrient content requiring the FCDB to be kept up-to-date (Harrington et al., 2019; Kapsokefalou et al., 2019). Today's usage of technology such as web-scraping, undertaken to create FoodDB in the UK (Harrington et al., 2019), allows regular collection of data for a large number of local food products. This provides up-to-date BOP data for branded products, overcoming limitations using traditional methods that rely on contacting food suppliers, or visits to supermarkets (Harrington et al., 2019). Since this technique was not available for our work, we obtained branded products' data by hand from companies' websites and product BOP labels.

The current work created the Arabic FCDB containing Arabic composite dishes and branded products available for Saudi Arabia and

Kuwait, which has been integrated into an Arabic version of the online dietary assessment tool, myfood24. This development was based on the existing food databases available for these two countries following the same standard approach used to create the food composition data for myfood24.

Our approach of mapping foods to items that had complete nutrient data from CoFID allowed the missing nutritional information to be imputed. However, some nutrient values, especially for micronutrients such as sodium, potassium, and calcium, may not accurately reflect the composition of any single food. Whilst the database aimed to include all relevant foods consumed in the region, due to limited national consumption data, limited pre-existing tables and unavailability of data (e.g. other branded foods, fast food and local restaurants) some foods may have been missed. These will be incorporated with future updates to include more composite dishes and branded foods and expand it for other Gulf and Middle Eastern countries.

5. Conclusions

The Arabic FCDB has been developed which includes 2016 items consisting of composite foods, branded products, and generic foods that are commonly consumed in Saudi Arabia and Kuwait. The database includes data on 120 nutrients for all foods and these have been linked to multiple portion size options. The current work has been integrated into the fully Arabic version of the online dietary assessment tool, myfood24; the first comprehensive online tool designed to facilitate nutritional epidemiological studies and help in measuring the dietary intake of Arabic-speaking populations. Regular updates and expansion of the database are planned to offer more food items from a wider range of Middle Eastern countries.

Declaration of Competing Interest

JEC, NH, SB, LG and GW are involved in Dietary Assessment Ltd.

Funding

A.O.B is a PhD student in receipt of a scholarship from King Abdulaziz University, Jeddah, Saudi Arabia.

CRediT authorship contribution statement

Areej Bawajeeh: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft. **Sondos Kalendar:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation. **Giulia Scarpa:** Writing - review & editing. **Neil Hancock:** Methodology, Software, Writing - review & editing. **Sarah Beer:** Methodology, Software, Validation. **Lauren Gibson:** Methodology, Software. **Grace Williams:** Methodology, Software, Validation. **Basma Dashti:** Resources, Writing - review & editing. **Salwa Albar:** Conceptualization, Methodology, Writing - review & editing. **Hannah Ensaff:** Writing - review & editing, Supervision. **Michael A. Zulyniak:** Writing - review & editing, Supervision. **Charlotte E. Evans:** Writing - review & editing, Supervision. **Janet E. Cade:** Conceptualization, Methodology, Writing - review & editing, Supervision.

Acknowledgments

We would like to acknowledge Joan Ransley, in training and providing guidelines on taking pictures of foods, and Miles Ratcliffe for his consultations during quality checking.

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.2021.104047.

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