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Specialized food composition dataset for vitamin D content in foods based on European standards: Application to dietary intake assessment

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ABSTRACT

A review of national nutrition surveys from 2000 to date, demonstrated high prevalence of vitamin D intakes below the EFSA Adequate Intake (AI) (< 15 µg/d vitamin D) in adults across Europe. Dietary assessment and modelling are required to monitor efficacy and safety of ongoing strategic vitamin D fortification. To support these studies, a specialized vitamin D food composition dataset, based on EuroFIR standards, was compiled. The FoodEXplorer™ tool was used to retrieve well documented analytical data for vitamin D and arrange the data into two datasets - European (8 European countries, 981 data values) and US (1836 data values). Data were classified, using the LanguaL™, FoodEX2 and ODIN classification systems and ranked according to quality criteria. Significant differences in the content, quality of data values, missing data on vitamin D_2 and 25(OH)D_3 and documentation of analytical methods were observed. The dataset is available through the EuroFIR platform.

1. Introduction

Vitamin D intake is inadequate throughout Europe. A review of European national surveys from the year 2000 onwards showed that vitamin D intakes ranged from 3 to 7.5 µg/d in Europe, depending on the country, being well below AI (15 µg/d vitamin D, set by the EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), based on minimal sun exposure) (EFSA Panel on Dietetic Products Nutrition and Allergies (NDA), 2016). The prevalence of inadequate intake is 77–100% of adults (19–64 y) and 55–100% of elderly adults (> 64 y) (Roman Viñas et al., 2011).

Many people do not consume dietary food sources of vitamin D (eggs, oily fish, meat, dairy, mushrooms) in amounts sufficient to meet daily requirements. Usual vitamin D intakes from food are higher in the US (Moore, Radcliffe, & Liu, 2013) than in most of Europe, with the exception of the Nordic countries (Spiro & Buttriss, 2014), partly due to the established fortification practices (Calvo, Whiting, & Barton, 2004; Laaksi et al., 2006; Tylavsky, Cheng, Lyytikainen, Viljakainen, & Lamberg-Allardt, 2006), but also because of a higher degree of supplementation with vitamin D (Hilger et al., 2014). Undoubtedly, nutritional supplements can contribute significantly to an individual's total vitamin D intake. Particularly, infants and elderly adults are more prone to supplement use (Whiting, Langlois, Vatanparast, & Greene-Finestone, 2011) than are children, adolescents and young adults, who may also be at higher risk of deficiency due to rapid skeletal development (Black, Walton, Flynn, & Kiely, 2013). However, studies have shown that vitamin D supplements differ in vitamin D content and the percentage of the population taking them is relatively low (Cashman & Kiely, 2014). Even though fortifications of food with vitamin D offer a wider reach and impact on the population, compared to supplements, they focus on a limited range of food types, such as dairy products or margarine, and miss out those population groups who do not consume those fortified products, making these strategies insufficiently effective. (Fulgoni, Keast, Bailey, & Dwyer, 2011). Thus, experts suggest that well-designed and targeted fortification strategies, which use a range of foods to accommodate diversity, and also include an appropriate level of added vitamin D, would have the potential to increase vitamin D intakes across the population distribution and minimize the prevalence of vitamin D deficiency in the long term (Kiely & Black, 2012). In order to harness these strategies, the

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ODIN project (European Commission-funded project, *Food based solutions for optimal vitamin D nutrition and health throughout lifecycle* - http://www.odin-vitd.eu/) aimed to facilitate consistent collection and reporting of nationally representative intake data on vitamin D from fortified foods, supplemental sources and the base diet (Kiely, Cashman, & Consortium, 2015).

Scientists studying vitamin D require up-to-date high-quality food composition data (based on analytical data) with improved coverage of both total vitamin D content and vitamers [D_2, D_3 and 25-hydroxyvitamin D_3 (25(OH)D_3)] in staple foods, fortified foods and composite dishes to be able to estimate vitamin D intakes from the diet and perform predictive modelling to develop fortification practice and/or design intervention studies to test (bio)fortification strategies in terms of their ability to raise intakes and serum 25(OH)D_3 levels without compromising safety (Kiely et al., 2015)

The aim of this study was to create a specialized dataset on vitamin D content in foods, with the best available analytical data, across European food composition databases, and to identify natural vitamin D containing foods for potential biofortification strategies and fortified food products. The specialized dataset would be used for supporting dietary assessment in other ODIN studies and for future dietary assessment studies.

2. Materials and methods

2.1. General approach

A compilation of food composition data for vitamin D in foods was undertaken using the updated EuroFIR FoodEXplorer™ tool. FoodEXplorer™ presents an online platform that hosts 30 national food composition databases and includes > 40,000 food items (EuroFIR AISBL, 2013). The preliminary screening of available vitamin D data was performed to identify potential national data sets that could satisfy the required criteria (Table 1), i.e. well documented analytical values of vitamin D forms: total vitamin D [as defined in EuroFIR component thesaurus, vitamin D_2 (ergocalciferol), vitamin D_3 (cholecalciferol) and 25(OH)D (25-hydroxycholecalciferol)]. Remaining values were calculated, estimated or imputed, and thus excluded from further consideration. Other sources of analytical values were extracted from recent scientific literature, where samples may not be representative of foods consumed nationally.

A schematic overview of the methodology in this work is presented in Fig. 1.

The data were collected using two approaches:

1) **From FoodEXplorer™** - analytical data on vitamin D were retrieved, applying a protocol for selection of search criteria as presented in Table 1. Vitamin D data, based on analytical values alone, were identified in six national food composition data sets: Finland (National Institute for Health & N. U., 2010); France (French Agency for Food Environmental & Safety, 2008); the Netherlands (RIVM, 2013); Sweden (National Food Agency, 2013); and the USA (U.S. Department of Agriculture, 2013). Norway was also identified as having well documented analytical data from food manufacturers, and therefore was included as a potential source of information to fill the gaps on some foods that might be an important source of vitamin D, e.g. oily fish, fortified spreads etc. (NFSA, 2009). A comprehensive data search protocol, designed to ensure complete extraction of well documented analytical data of vitamin D from FoodEXplorer™, required the combinations of two types of entities: *Food components* (Vitamin D, Cholecalciferol and 25(OH)D_3 and combination of two or three of these elements) and *analytical identifiers* for each vitamer. Analytical identifiers were specific analytical methods (HPLC, a standard analytical method for vitamin D determination) or general analytical results ("analytical methods", "analytical results", "analytical, generic"). Besides this, the advanced search function in FoodEXplorer™ enabled choice of a FOOD ATTRIBUTE, in this case FOOD GROUP, and finally, country of interest (EuroFIR AISBL, 2013). Food groups of interest were identified previously as those with potential to yield a vitamin D value greater than zero. These search parameters are shown in Table 1. Manufacturers' data collated in databases were also considered, as they were significant sources of information for functional foods/fortified formulations. These data were without reference method documentation, but were anticipated to be of analytical origin, as manufacturers needed the data to communicate nutritional benefits of these products.
2) **Outside FoodEXplorer™** - In the compilation of this dataset, additional data, sourced from scientific literature not available in national datasets, were considered. Analytical data produced by the DTU laboratory in Denmark (which was the ODIN project analytical centre for vitamin D in foods) were also included (Jakobsen, Clausen, Leth, & Ovesen, 2004; Jakobsen & Saxholt, 2009). In these studies, data on meat and dairy products were obtained by an HPLC method. Newly published Turkish food composition data, (TÜBİTAK, 2014) and data from the new version of McCance & Widdowson's The Composition of Foods from the United Kingdom (Finglas et al., 2015) were also included.

Table 1
Search protocol: Terms applied in data search on FoodEXplorer™.

Vitamin D value data source	– Analytical results, analytical, generic, analytical methods (non-defined), HPLC
Vitamin D forms	– Vitamin D – total – Cholecalciferol (D_3) – 25-hydroxycholecalciferol (25OHD_3)
Country datasets	– USDA – UK FCD – DTU – French FCDB – Dutch FCDB – Swedish FCDB – Norwegian FCDB – Finnish FCDB – Turkish FCDB
Food groups (merged EuroFIR food groups and ODIN groups & sub-groups)	– FISH AND SEA FOOD – MEAT AND MEAT PRODUCTS – DAIRY o NON-FORTIFIED o FORTIFIED – NON DAIRY DRINKS o FORTIFIED – FAT AND FATTY SPREADS o BUTTER o FORTIFIED OILS AND MARGARINES – EGGS o NON-FORTIFIED o FORTIFIED – MUSHROOMS o FORTIFIED – BAKERY YEASTS o FORTIFIED – FORTIFIED JUICES – FORTIFIED CEREALS PRODUCT – MEAL REPLACEMENT (FORMULATED LIQUID DIETS)

Separate data extraction was performed from the United Stated Department of Agriculture database (USDA, SR26). The USDA dataset was not harmonised with EuroFIR standards, i.e. nutrient identifiers were defined as total vitamin D (in IU), Vitamin $D_2 + D_3$, vitamin D_2 and vitamin D_3, while 25(OH)D forms were missing and, thus, the dataset was treated separately. Total Vitamin D was expressed in IU/100 g, and needed to be converted to μg/100 g for comparison with European data. Besides that, analytical method descriptors were defined as "analytical data" and "analytical or derived from analytical data" and