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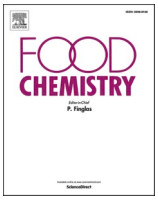

The first harmonised total diet study in Portugal: Vitamin D occurrence and intake assessment

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ABSTRACT

Vitamin D acts in calcium and phosphate homeostasis and also as an immunomodulatory hormone. To estimate the vitamin D intake by the 'adults' and 'elderly' Portuguese populations TDS methodology was used, since in the absence of skin UVB exposure, food and supplements are the only vitamin D sources. Vitamin D was quantifiable in 78 (24 from the fish group) of the 164 TDS samples. Sea bream contained the most vitamin D (13.8 μg/100 g), followed by plaice (9.2 μg/100 g). MCRA software (semi-probabilistic approach) was used to estimate the median vitamin D intake that ranged between 2.47 ('adults' 'males') – 1.45 ('elderly' 'females') μg/day, well below the Dietary Reference Values (5–15 μg/day). Plaice, sea bream and sardine were the main contributors to intake. A prevalence of 94% inadequate vitamin D intake for 'adults' and 'elderly' was found based on the estimated average requirement of 10 μg/day.

1. Introduction

Vitamin D has an essential role in maintaining healthy bones and teeth, intervening in mineralization through the regulation of calcium and phosphate homeostasis (Fleet, 2017; Taylor & Bushinsky, 2009). In addition, it is an immunomodulatory hormone (Prietl et al., 2013) and, more recently, some authors have reported positive effect in combating COVID-19 (Charoenngam & Holick, 2020). Furthermore, vitamin D has important functions in the proliferation and differentiation of cells, signalling of neurotransmitters, contraction of muscles, regulation of the heartbeat and coagulation of blood (DeLuca, 1986).

In nature, vitamin D exists in two forms, D_2 (ergocalciferol) and D_3 (cholecalciferol), both present in food. Humans can synthesise vitamin D3 from 7-dehydrocholesterol at skin level in the presence of sunlight ultraviolet B radiation (UVB) and store it in the adipose tissue. After its absorption in the upper part of the small intestine with the help of bile salts or after endogenous synthesis, vitamin D has to be converted to exert its biological functions. It is then transformed, in the liver, into calcidiol (25-(OH) D), the form usually used as a biomarker of vitamin D status in humans and, subsequently, in the kidney, into calcitriol (1,25-di(OH) D), the biologically active form, which is considered a hormone (Aponaro et al., 2020).

According to the Portuguese General Directorate of Health, sun exposure of the hands, face and legs, for 5 to 15 min, two to three times a week, are enough to keep vitamin D levels high (Direção Geral da Saúde [DGS]). However, there are many factors affecting the synthesis of vitamin D_3 that need to be considered. Factors that depend on the individual, such as time spent outdoors, use of sunscreen, clothing, skin colour and age, and external factors such as latitude, season, ozone layer thickness and clouds (European Food Safety Authority [EFSA], 2016).

UVB reach the Earth with higher intensity between 12 pm and 4 pm and data suggest that in the northern hemisphere and consequently in Europe the duration of vitamin D "winters" ranges from zero (up to 35° N latitude) to eight months (at 69° N latitude) (O'Neill et al., 2016; Kift et al., 2018). Continental Portugal and Azores Islands are located roughly at a latitude between 37° N and 42° N, therefore, dietary vitamin D intake is essential at least in December and surrounding months. Diet is also a crucial source of vitamin D for people that are not exposed to UVB sunlight for other reasons (e.g. institutionalized people).

According to the Portuguese Food Composition Table (Instituto Nacional de Saúde Doutor Ricardo Jorge [INSA], 2021), the main sources of dietary vitamin D in Portugal are fat fishes (e.g. sardine, conger, sea bream, trout, plaice, salmon) (10–91 μg/100 g), egg yolk (5 μg/100 g), fortified foods such as vegetable spreads (5 μg/100 g) and breakfast cereals (3 μg/100 g). In addition, several vitamin D supplements are available in the market. However, the effectiveness of vitamin D supplementation has been questioned by several studies because its absorption is generally low (Hayes & Cashman, 2017).

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The ODIN project (Cashman et al., 2017) performed for the first time an individual participant data (IPD)-level meta-regression of the vitamin D intake–serum 25-hydroxyvitamin D (25(OH)D) dose–response. The study was based on seven randomized controlled trials, conducted in winter, with 882 participants aged between 4 and 90 years old. According to the previous authors, the estimated Recommended Dietary Allowance (for 97.5% of the population) was 10 μg/day to prevent deficiency (level of 25-(OH) D < 25 nmol/L) and 26 μg/day to prevent insufficiency (level of 25-(OH) D < 50 nmol/L). These values are higher than those recommended by other Organisations based on standard meta-regression which does not allow to distinguish the variability between people. At European level the Regulation 1169/2011 on the labelling of foodstuffs states a reference daily intake of 5 μg/day, and EFSA reports an adequate intake (AI), assuming minimal sun exposure, of 10 μg/day for infants and 15 μg/day for children and adults (European Union [EU], 2011; EFSA, 2016). In USA, the Institute of Medicine (IoM), in 2011, updated the Estimated Average Requirement (EAR) to 10 μg/day, for individuals aged one year old and over. In addition, the Recommended Dietary Allowance was established at 15 μg/day and 20 μg/day for individuals 1–70 years old and aged 71 years and older, respectively, also based on conditions of minimal sun exposure (Institute of Medicine (IoM), 2011).

In Europe, national food surveys indicate average intake of 3–7 μg/day (Cashman et al., 2017). The Portuguese National Food, Nutrition and Physical Activity Survey (2015–2016) reported vitamin D intake medians of 4.9, 3.8, 3.7, 3.7 μg/day, for children below 10 years old, adolescents (10–17 years old), adults (18–64 years old) and elderly (65–84 years old), respectively. Intake results were obtained after adjusting for intra-individual variability and weighting for the distribution of the Portuguese population and included the consumption of food supplements (Lopes et al., 2018).

Total Diet Studies (TDS) are recognized as an adequate cost-effective tool for the assessment of contaminants exposure and nutrients intake by a population because they consider the whole diet represented by pooled samples composed of foods as consumed and not as available on the market. Therefore, an international effort was made to harmonise the TDS methodology through a joined initiative by WHO, FAO and EFSA followed by a research project financed by the European Commission in order to promote the comparability of exposure and intake estimates within and between countries and to allow trend analysis (World Health Organization [WHO], 2005; EFSA, Food and Agriculture Organization of the United Nations (FAO), WHO, 2011; Pité et al., 2018).

The aim of the study was to assess dietary intake of vitamin D by the Portuguese population using a harmonised TDS methodology and evaluate intake based on European and International dietary reference values (DRVs) in order to complement existing information supporting health policy decisions.

2. Material and methods

Vitamin D intake by the Portuguese population was evaluated based on the Total Diet Study (TDS) methodology, following harmonised procedures developed in the scope of TDS-Exposure project (Dofkova et al., 2016; Pité et al., 2018; Kolbaum et al., 2019) respecting the principles given in the international publication "Towards a harmonised Total Diet Study approach: guidance document" (EFSA, FAO, WHO 2011). The study was conducted by the Food and Nutrition Department of INSA (National Institute of Health Doctor Ricardo Jorge, IP) including the laboratory analytical work.

2.1. Food sampling

The process of defining and preparing the TDS samples to be analysed was previously described in detail (Vasco et al., 2021). In brief, a core food list of 1072 food items was derived from a 24 h recall food consumption survey conducted on 3470 individuals (52% female and 48% male) aged 18 to 93 years old, which was representative of the general Portuguese population (Poínhos et al., 2009). The FoodEx2 hierarchic food coding system from EFSA (EFSA, 2011) was used to classify the food items of the core list into 20 food groups. Subsequently, a TDS food list comprised of 528 food items representing the diet of the 'adults and elderly' (18 to 74 years old) 'male and female' groups of the Portuguese population ('overall population') was prepared considering at least 90% of the food consumption (excluding tap water) of 3272 individuals. The 90% criterion, together with the inclusion of food items assumed to be major contributors to the exposure to contaminants or to the intake of nutrients and not covered previously, was applied at food group level to ensure the representation of the overall diet diversity (Dofkova et al., 2016). The food items from the TDS food list were then aggregated into 164 TDS samples, using the individual or mixed approach, taking advantage of the FoodEx2 classification which also contributed to facilitate the ulterior laboratory analytical work by type of food matrices. Furthermore, considering regionality and seasonality, TDS samples were categorised as national (126), regional non-seasonal (17) and regional seasonal (21; one TDS sample per season) resulting in a total of 227 TDS samples for laboratory analysis. Each TDS sample was composed by twelve subsamples, each one prepared as consumed. The selection of food shops and the culinary treatment methods respected the Portuguese consumer behaviour. Culinary preparation was performed to obtain the subsamples from the food items collected between April 2014 and March 2016. The edible part of each subsample was pooled into the TDS sample which was then homogenised using a knife mill GRINDOMIX GM 300 (Retsch, Germany, Grindomix GM 300, 5 L volume), stored in plastic containers (HDPE) (VWR, Portugal), kept at −20 °C and defrosted in the refrigerator before analysis.

2.2. Vitamin D determination

All TDS samples were checked for the content of vitamin D and predictable logical zeros (plant origin samples, except mushrooms or fortified samples) were not subjected to laboratory analysis. The remaining TDS samples were analysed by a ISO/IEC 17025 accredited method based on the EN 12821: 2009: "Foodstuffs - Determination of vitamin D by high performance liquid chromatography - Measurement of cholecalciferol (D3) or ergocalciferol (D2)" (Comité Européen de Normalisation [CEN], 2009), consisting of a normal phase semi-preparative High Performance Liquid Chromatography (HPLC) method followed by a reverse phase analytical HPLC technique using UV detection. A Waters Alliance 2695 HPLC System coupled to a Waters 2996 PDA detector (Waters Corporation, Milford, MA, USA), with Empower Chromatography Data Software™ were used. Vitamin D identification and quantification was based on retention time and internal standard (response factor), respectively. The standard solutions of vitamin D were prepared from D_2 (ergocalciferol, CAS 67-97-0) and D_3 (cholecalciferol, CAS 50-14-6) standards, purity > 98%, from Sigma-Aldrich (Merck KGa A, Darmstadt, Germany) and the concentrations were evaluated by spectrophotometry (Evolution 300, ThermoFisher Diagnostics, Waltham, Massachusetts, United States).

The semi-preparative step (purification and concentration) was done using a LiChrosorb Si 60 column, with a particle size of 5 μm, and dimensions 250 mm (length)/4 mm (diameter) (Merck KGa A, Darmstadt, Germany). The mobile phase was composed by *n*-heptane (Merck KGaA, Darmstadt, Germany) and 2-propanol (Merck KGaA, Darmstadt, Germany), 97:3, flow rate 1 mL/min. Sample fractions containing vitamin D were collected in the retention time frame of the mixed vitamin D (D2 and D3) standard solution. The sample vitamin D was concentrated by collecting the fractions of two 200 μL sample injections, followed by evaporation and reconstitution in methanol. These solutions were further processed (analytical step) to quantify vitamin D using an injection volume of 100 μL, a Kromasil 100 C18, particle size of 5 μm, 250 mm/4 mm column (Merck KGa A, Darmstadt, Germany), a mobile phase of methanol (Merck KGa A, Darmstadt, Germany) and water in a 95:5

ratio, at a 0.8 mL/min flow rate. The identification was performed by comparison with individual vitamin D2 and D3 standard solutions and the quantification by internal standard method was performed using the response factor obtained through the injection of the mixed standard solution (D2 and D3). The criteria for the baseline definition were the same for samples and standards. All solutions were injected in duplicate. Sample vitamin D concentration was expressed in μg/100 g. The UV detection was carried out at a wavelength of 265 nm for both semi-preparative and analytical steps.

Before the HPLC steps, sample portions, ranging between 0.5 and 100 g (depending on the fat content and the presumed vitamin D content), were saponified using 100 mL of ethanol, 1 g of ascorbic acid and 7.5 mL of 60% potassium hydroxide solution. The saponified sample solution was extracted with 2:8 diethyl and petroleum ether, evaporated and reconstituted in HPLC semi-preparative mobile phase. The final extract was filtered through a PVDF (polyvinylidene difluoride) 0.45 μm filter before HPLC analysis. All reagents were from Merck KGa A, Darmstadt, Germany. All analyses were performed in duplicate.

In brief, the method limits of detection (LOD) and quantification (LOQ) were 0.02 and 0.06 μg/100 g, respectively and the working range was between 0.25 and 3.5 μg/mL. The measurement precision expressed by relative standard deviation ranged from 4.5 to 5.4 % for repeatability (RSDr) and from 9.6 to 11.3 % for intermediate precision (RSDR). Recovery was verified on a set of real samples representing different matrices, which were spiked with the mixture of standards of both vitamins. HPLC separation of vitamin D2 and D3 was controlled using the mixed standard solution in each chromatographic run. Accuracy was externally evaluated by the participation in proficiency testing (FAPAS, Food Analysis Performance Assessment Scheme, Food and Environment Research Agency (FERA), Science Ltd., UK, with Z-scores between −1.6 and 1.2 for the different food matrices analysed. The relative expanded uncertainty of the results was 29% (95% confidence level).

2.3. Vitamin D dietary intake evaluation

The population's dietary vitamin D intake was evaluated, based on a semi-probabilistic approach, by combining each TDS sample occurrence value with the recorded consumption by each individual participating in the food consumption survey of the food items represented by that sample. The mean occurrence value of the four seasonal samples was used. FoodEx2 food classification system from EFSA was used to link the occurrence analytical values with the consumption data, since one occurrence value could correspond to one to twelve food items (subsamples) and consequently to several consumption records of each individual participating in the survey. Monte Carlo Risk Assessment (MCRA) software was used to estimate the intakes, using the Observed Individual Mean (OIM) model (Kolbaum et al., 2019). The management of left-censored data (results reported below limit of detection and/or limit of quantification) was carried out by substitution (European Food Safety Authority (EFSA), 2010). The lower bound approach was used, which is the non-detected values were considered zero, and values between the limit of detection and the limit of quantification were set at the limit of detection, to avoid overestimation of vitamin D intake. The mean, 25th, 50th (median), 75th, and 95th percentiles of intake per day were calculated. The intakes, expressed in μg/day, were estimated by age groups and sex, for 'overall population', as well as, for 'adults and elderly', 'adults' and 'elderly' combined with 'male and female', 'male' and 'female', according to the structure of the survey (children were not included). The contribution of each food item to the total intake was estimated and the top five foods were identified.

All intake evaluations were done based on the values established by EFSA for the Adequate Intake (AI) and by the American IoM for the Estimated Average Requirement (EAR), both based on minimal sunlight exposure (UVB). Estimated intake values (medians) were qualitatively compared to AI, 15 μg/day for adults (EFSA, 2016). If the median intake was above the AI, the prevalence of inadequate intake in the population was considered low. On the contrary, if the median intake was below the AI, no conclusion could be done about the adequacy (van Rossum et al., 2011; Institute of Medicine (IoM), 2011). Based on the EAR (10 μg/day), it was assumed that the fraction of population with intake below this value was the fraction of individuals with inadequate intake (Institute of Medicine (IoM), 2011).

3. Results and discussion

3.1. Vitamin D occurrence

Vitamin D occurrence results (minimum, maximum) by FoodEx2 group complemented by other information characterising the food groups (e.g. number of TDS samples with values considered left-censored) are presented in Table 1. Sixty-nine TDS samples (42.1%) were identified as logical zeros for vitamin D and 17 analysed samples (10.4%) presented values below the LOD. Seventy-eight of the 164 TDS samples presented values equal or above the LOQ. No TDS samples had a vitamin D content between the detection and quantification limits.

Vitamin D content of TDS samples organised by food group is provided in Table 2; all results correspond to vitamin D3, with the exception of mushrooms that contain vitamin D2.

The highest vitamin D content was found in the 'Fish, seafood, amphibians, reptiles and invertebrates' food group. There was a great variation in vitamin D among species from sea bream (13.8 μg/100 g) and European plaice (9.2 μg/100 g) to hakes (0.29 μg/100 g) and marine shrimps or prawns (<LOD). Milešević et al. (2018) reported vitamin D value ranges (μg/100 g) for salmon farmed (4.7–11.3), mackerel (3.2–7.4), canned sardine in oil (3.3–10.8). In this work, values obtained for salmon, chub mackerel and canned sardine samples fall into the previous ranges. The values published in the Portuguese Food Composition Table (INSA, 2021) compared with the ones obtained in this work are higher for conger (91 μg/100 g), salmon (9–11 μg/100 g), hakes (1.5–1.6 μg/100 g) and lower for sea bream (7.9–8.4 μg/100 g), chub mackerel (1.4–2.3 μg/100 g), sardine (0.7–2.4 μg/100 g), dried salted soaked codfish (0.4 μg/100 g), canned tuna in oil (0.4 μg/100 g) and ling (0.4 μg/100 g).

For the 'Vegetables and vegetable products' and the 'Products for non-standard diets, food imitates and food supplements or fortifying agents' groups, only one sample in each group had a result above the LOQ, the Common/portobello/champignon mushroom (4.1 μg/100 g) and soya drink (0.75 μg/100 g). The values obtained for common/portobello/champignon mushroom were in agreement with the literature (1–10 μg/100 g) (Cardwell et al., 2018).

Regarding the 'Eggs and egg products' food group represented by a single TDS sample, composed by boiled, fried, scrambled and pouched eggs, the vitamin D value obtained (1.3 μg/100 g) was in accordance with the literature (0.8–3.2 μg/100 g, whole, raw) (Milešević et al., 2018).

For the 'Composite dishes', no comparable values were found in the literature since most TDS samples represented Portuguese typical dishes.

For the 'Milk and dairy products' the values obtained in this work were in accordance with the literature with the exception of spoonable dairy desserts which could be explained by different recipes in different countries. Milešević reported vitamin D values of 0.01–1.4 μg/100 g for cow milk and 0.1–1.2 μg/100 g for dairy (yogurts, pudding, chocolate milks, cheeses) (Milešević et al., 2018).

The top five TDS samples with the highest vitamin D content were, in μg/100 g, sea bream (13.8), European plaice (9.2), canned sardine in oil (8.6), coastal marine fishes (wrasse, pouting, blackspot sea bream, red porgy) (7.3) and European sardine (6.7).

The seasonal effect on vitamin D was studied in chub mackerel and European sardine TDS samples. Taking into account the expanded uncertainty of the measurement results (confidence interval, 95%), for chub mackerel, vitamin D in summer (6.2 μg/100 g) was significantly higher than in winter, spring and autumn (3.3, 2.7, 2.3 μg/100,

Table 1
Vitamin D content in TDS samples by FoodEx2 food group.

FoodEx2 food group number	FoodEx2 Level 1 food Groups	Total Nr of food items	Nr of food items selected for the TDS food list	Nr of TDS Samples	Nr of TDS Samples logical zero	Nr of TDS Samples < LOD	Nr of TDS Samples ≥ LOQ	Vitamin D* (μg/100 g) (≥LOQ)	
								Minimum	Maximum
2	Alcoholic beverages	28	7	2	2	0	0	–	–
3	Animal and vegetable fats and oils	7	3	2	1	0	1	0.70	0.70
4	Coffee, cacao and tea and infusions	12	9	4	4	0	0	–	–
5	Composite dishes	360	191	34	5	8	21	0.10	2.48
6	Eggs and egg products	2	1	1	0	0	1	1.34	1.34
7	Fish, seafood, amphibians, reptiles and invertebrates	68	41	25	0	1	24	0.29	13.78
9	Fruit and fruit products	65	15	14	14	0	0	–	–
10	Fruit and vegetable juices and nectars	43	38	2	2	0	0	–	–
11	Grains and grain-based products	158	67	21	5	3	13	0.10	2.50
12	Legumes, nuts, oilseeds and spices	21	11	8	8	0	0	–	–
13	Meat and meat products	68	49	11	0	3	8	0.10	0.70
14	Milk and dairy products	89	30	6	0	0	6	0.079	2.70
15	Products for non-standard diets, food imitates and food supplements or fortifying agents	9	4	2	1	1	1	0.15	0.15
16	Seasoning, sauces and condiments	22	14	5	2	1	1	0.50	0.50
17	Starchy roots or tubers and products thereof, sugar plants	7	1	1	1	0	0	–	–
18	Sugar, confectionery and water-based sweet desserts	23	12	3	2	0	1	0.60	0.60
19	Vegetables and vegetable products	46	22	19	18	0	1	4.10	4.10
20	Water and water-based beverages	40	13	4	4	0	0	–	–
Total		1068	528	164	69	17	78		

LOD, limit of detection (0.02 μg/100 g); LOQ, limit of quantification (0.06 μg/100 g); *Vitamin D_3 for all food groups, except for group 19, vitamin D2.

respectively) and no significant difference was observed among these three seasons. Regarding European sardine, the vitamin D content in spring (3.8 μg/100 g) is significantly lower than in winter and autumn (7.1, 9.1 μg/100 g, respectively) and the content in summer (6.6 μg/100 g) is not significantly different from other seasons. All seasonal sardine TDS samples included frozen and fresh sardines in different proportions in order to reflect market availability in each season. Therefore, no direct conclusion could be made regarding the impact of season on sardine vitamin D content.

3.2. Vitamin D dietary intake evaluation

All vitamin D analytical results below the limit of detection were considered zero in the evaluations made using the MCRA software (lower bound) in order to avoid underestimation of inadequacy prevalence.

Estimated vitamin D intake in the Portuguese population (18 to 75 years old) by age and sex is presented in Table 3 together with the mean intake and contribution by FoodEx2 food group. Vitamin D mean intake in the population groups studied varied between 3.13 (‘elderly’ ‘males’) and 3.78 μg/day (‘adults’ ‘males’), with 3.49 μg/day for the ‘overall population’. In ‘male and female’ ‘adults’ and ‘male and female’ ‘elderly’ the estimated mean intake was 3.54 and 3.20 μg/day, respectively. ‘Adults’ showed higher vitamin D intake in all population groups (‘male and female’, ‘male’ and ‘female’) when compared with the respective ‘adults and elderly’ population; however, the differences found were less than 3%. The ‘elderly’ ‘male’ population presented the lowest vitamin D mean intake, 3.13 μg/day, approximately 15% less than the total male population (‘adults and elderly’). A vitamin D mean intake of roughly 3.3 μg/day was found for all female age groups.

When considering vitamin D median intake (P50) it was found a substantial difference relatively to the mean (2.16 vs 3.49 μg/day, for ‘overall population’), indicating a distribution heavily skewed to the left (large proportion of individuals with low intakes). The ‘female’ population showed the lowest vitamin D median intake in all age groups, differing roughly 10% when compared with the ‘overall population’. Differences of less 17% (‘adults’) and 28% (‘elderly’) were found for ‘females’ when compared with the respective ‘male’ age groups (Table 3).

The most recent assessments made by EFSA point to 15 μg/day as a suitable intake for the majority of adult population (97.5%) to achieve the target serum 25(OH)D concentration of 50 nmol/L, under conditions of assumed minimal skin vitamin D synthesis (EFSA, 2016).

Vitamin D intake by 50% of the studied Portuguese population groups ranged from 2.47 μg/day (‘adults’ ‘males’) to 1.45 μg/day (‘elderly’ ‘females’), well below the adequate intake reference value preconized by EFSA, therefore the risk for inadequate intake cannot be considered low (EFSA, 2016). Only 2.58% of the studied individuals achieved the adequate intake.

The prevalence of inadequacy of vitamin D intake in the Portuguese ‘overall population’ is around 94% when the intake distributions obtained in this study are compared with the estimated average requirement (EAR) of 10 μg/day (Institute of Medicine (IoM), 2011). These results are based on diet only, excluding supplements, since the

Table 2
Vitamin D content of each TDS sample.

FoodEx2 Food Group Nr	FoodEx2 Level 1 Food Group	TDS Sample Nr	TDS Sample	Vitamin D content µg/100 g
2	Alcoholic beverages	1	Beer	LZ
2		2	Wine	LZ
3	Animal and vegetable fats and oils	4	Butter	0.70
3		3	Olive oils	LZ
4	Coffee, cacao and tea and infusions	5	Cocoa ingredients	LZ
4		6	Coffee beverages	LZ
4		8	Herbal and other non-tea infusions	LZ
4		7	Tea infusion (black, white)	LZ
5	Composite dishes	12	Beans and meat meal (beans and gut dish)	<LOD
5		13	Beans, meat, and vegetables meal (meat and vegetables boiled dish, Portuguese style)	0.10
5		14	Beans, meat, and vegetables meal (beans stewed with pork and cow meat)	0.10
5		15	Beans, meat, and vegetables meal (pork mest, chickpea, pasta and vegetables stewed)	0.10
5		9	Dishes, incl. Ready to eat meals (excluding soups and salads) (bread based fish)	0.31
5		30	Finger food	0.20
5		22	Fish and potatoes meal (cod fish dishes)	1.40
5		23	Fish and potatoes meal (mixed fish stew)	6.20
5		24	Fish and potatoes meal (potato puree with fish)	0.60
5		25	Fish and rice meal	1.37
5		19	Fish and seafood based dishes	1.40
5		40	Fish soup	<LOD
5		31	Lasagna	0.10
5		36	Legume (beans) soup	LZ
5		18	Meat balls	0.50
5		16	Meat based dishes	0.20
5		17	Meat burger (no sandwich)	0.40
5		39	Meat soup, with pieces (chicken soup)	<LOD
5		42	Mixed vegetable salad (tomato and lettuce salad)	LZ
5		43	Mixed vegetable salad (russian salad)	0.10
5		37	Mixed vegetables soup (green cabbage soup)	<LOD
5		38	Mixed vegetables soup, with puree or pieces	LZ
5		27	Omelette, plain	2.48
5		29	Pizza and pizza-like dishes	<LOD
5		10	Potato based dishes (mashed potatoes)	<LOD
5		11	Potatoes and meat meal (potato puree with meat)	0.20
5		21	Prepared fish salad	<LOD
5		26	Quiche	1.66
5		34	Rice and meat meal	0.10
5		33	Rice and vegetables meal	LZ
5		32	Rice based dishes cooked	0.50
5		28	Sandwich with meat and vegetable topping/filling	<LOD
5		20	Seafood-based meals	0.15
5		35	Tomato soup	LZ
6	Eggs and egg product	44	Hen eggs	1.30
7	Fish, seafood, amphibians, reptiles and invertebrates	62	Bivalve molluscs	0.50
7		67	Canned fish in oil (tuna)	1.00
7		68	Canned fish in oil (sardine)	8.60
7		45	Catfishes (freshwater)	2.70
7		52	Cod, atlantic	0.50
7		65	Cod, dried	0.70
7		50	Conger, European	4.50
7		66	Fish fingers, breaded	2.80
7		53	Hakes	0.29
7		55	Horse mackerel	1.40
7		54	Ling	1.80
7		56	Mackerel, chub	3.60
7		61	Marine shrimps or prawns, cooked	<LOD
7		63	Octopus, common	0.70
7		49	Other coastal marine fishes (wrasse, pouting, blackspot seabream, red porgy)	7.30
7		60	Other pelagic marine fishes (forkbeard, red fish)	1.00
7		59	Other demersal marine fishes (scabbardfish)	1.70
7		46	Perch, Nile	3.30
7		51	Plaice, European	9.20
7		47	Salmon, Atlantic	4.70
7		57	Sardine, European	6.70
7		48	Sea Bream	13.78
7		64	Squid, common	1.00
7		69	Terrestrial snails, edible	3.10
7		58	Tuna	3.50
9	Fruit and fruit products	71	Apple	LZ
9		77	Banana	LZ
9		83	Canned or jarred fruit	LZ
9		80	Dried figs	LZ
9		79	Dried vine fruits (raisins etc.)	LZ
9		82	Fruit salad	LZ
9		81	Jam	LZ
9		76	Kiwifruit	LZ
9		70	Orange, sweet	LZ

(*continued on next page*)

Table 2 (*continued*)

FoodEx2 Food Group Nr	FoodEx2 Level 1 Food Group	TDS Sample Nr	TDS Sample	Vitamin D content µg/100 g
9		75	Peach	LZ
9		72	Pear	LZ
9		78	Pineapple	LZ
9		74	Strawberry	LZ
9		73	Table-grapes	LZ
10	Fruit and vegetable juices and nectars	84	Fruit juices	LZ
10		85	Fruit nectar	LZ
11	Grains and grain-based products	92	Biscuits, chocolate	<LOD
11		91	Biscuits, sweet, plain	0.60
11		93	Cakes	0.10
11		95	Chocolate cakes	2.50
11		89	Crackers	<LOD
11		100	Croissant	0.10
11		102	Flan tart	0.20
11		96	Fruit cake	1.70
11		103	Fruit pie-tarts	0.30
11		97	Muffins	0.50
11		90	Pasta and similar products	LZ
11		106	Popcorn (maize, popped)	LZ
11		105	Processed and mixed breakfast cereals	1.96
11		86	Rice grains (p)	LZ
11		101	Shortcrust (pies -tarts)	<LOD
11		87	Single grain bread and rolls	LZ
11		94	Sponge cake	0.90
11		104	Various pastry	0.60
11		88	Wheat bread and rolls, white (refined flour)	LZ
11		98	Yeast leavened pastry (leavened cake)	0.10
11		99	Yeast leavened pastry (brioche)	0.60
12	Legumes, nuts, oilseeds and spices	109	Beans (dry seeds)	LZ
12		107	Broad bean (fresh seeds)	LZ
12		110	Chick-pea (dry seeds)	LZ
12		111	Cowpea (dry seeds)	LZ
12		112	Lupin (dry seeds)	LZ
12		113	Peanut	LZ
12		108	Peas (fresh seeds, without pods)	LZ
12		114	Table olives for consumption	LZ
13	Meat and meat products	115	Bovine fresh meat	0.60
13		116	Calf fresh meat	0.10
13		120	Chicken fresh meat	0.60
13		123	Cooked cured meat (cooked ham)	<LOD
13		124	Dry and fermented sausages	<LOD
13		125	Frankfurter type sausage	<LOD
13		119	Rabbit fresh meat	0.50
13		122	Raw cured meat (ham and bacon)	0.50
13		118	Sheep fresh meat	0.40
13		117	Swine fresh meat	0.70
13		121	Turkey fresh meat	0.20
14	Milk and dairy products	129	Acidophilus milk	0.12
14		126	Cow milk	0.079
14		131	Dairy desserts spoonable	2.70
14		130	Firm - ripened cheeses	0.48
14		127	Flavoured milks	0.11
14		128	Yoghurt	0.22
15	Products for non-standard diets, food imitates and food supplements or fortifying agents	132	Meat imitates	LZ
15		133	Soya drink	0.75
16	Seasoning, sauces and condiments	137	Mayonnaise	0.50
16		138	Other common table-top condiments	<LOD
16		134	Stock cubes or granulate, meat	<LOD
16		136	Tomato ketchup	LZ
16		135	Vinegar	LZ
17	Starchy roots or tubers and products thereof, sugar plants	139	Potato boiled	LZ
18	Sugar, confectionery and water-based sweet desserts	141	Chocolate and chocolate products	0.60
18		142	Gelatine dessert	LZ
18		140	White sugar	LZ
19	Vegetables and vegetable products	149	Asparagus	LZ
19		158	Beans, green with pods	LZ
19		143	Broccoli	LZ
19		145	Brussels sprouts	LZ
19		159	Carrot	LZ
19		144	Cauliflower	LZ
19		153	Common melon varieties	LZ
19		160	Common/ portobello/ champignon mushroom	4.07
19		155	Lettuce	LZ
19		152	Melons (except watermelon)	LZ
19		148	Onion Bulb	LZ
19		156	Other leafy vegetables (Rapini)	LZ
19		151	Peppers, sweet	LZ
19		147	Portugese cabbage	LZ
19		161	Sweet corn canned	LZ
19		150	Tomato and similar (p)	LZ
19		157	Turnip greens	LZ
19		154	Watermelon	LZ
19		146	White cabbage	LZ
20	Water and water-based beverages	166	Cola beverages, caffeinic	LZ
20		164	Soft drink, mixed flavours	LZ
20		165	Soft drink, orange flavour	LZ
20		163	Still natural mineral water	LZ

LZ - Logical zero, LOD - Limit of detection.

consumption survey used in this research did not evaluate their consumption. The proportion of the population with intakes below the EAR is greater for the one-day distribution than for a distribution of usual nutrient intakes resulting in an overestimation of prevalence of inadequacy.

Regarding the Tolerable Upper Intake Level (EFSA, 2016) – 100 µg/day, it was overtaken by 0 % of the population. Based on MCRA calculations, the maximum intake observed for the 'overall population' was 72 µg/day.

These results are in line with those of other investigations conducted in Europe. Viñas et al. (2011) demonstrated (studies between 1994 and 2007) that eleven countries showed a range between 46.6 and 100% of

Table 3
Estimated dietary intake of vitamin D by the Portuguese population.

		Sex	Male and Female						Male						Female					
		Age group	18-74		18-64		65-74		18-74		18-64		65-74		18-74		18-64		65-74	
		Nr Individuals	3272		2752		520		1583		1363		220		1689		1389		300	
		Nr Food items "as eaten"	527		502		324		443		424		251		463		441		273	
FoodEx2 Food Group Nr	FoodEx2 Level 1 Food Group		Mean intake for all individuals	Contribution	Mean intake for all individuals	Contribution	Mean intake for all individuals	Contribution	Mean intake for all individuals	Contribution	Mean intake for all individuals	Contribution	Mean intake for all individuals	Contribution	Mean intake for all individuals	Contribution	Mean intake for all individuals	Contribution	Mean intake for all individuals	Contribution
			(µg/day)	%	(µg/day)	%	(µg/day)	%	(µg/day)	%	(µg/day)	%	(µg/day)	%	(µg/day)	%	(µg/day)	%	(µg/day)	%
2	Alcoholic beverages		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Animal and vegetable fats and oils		0.02	0.72	0.02	0.68	0.03	0.94	0.03	0.75	0.03	0.70	0.04	1.15	0.02	0.68	0.02	0.65	0.03	0.79
4	Coffee, cacao and tea and infusions		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Composite dishes		0.77	21.97	0.80	22.60	0.58	18.25	0.87	23.46	0.90	23.75	0.67	21.24	0.67	20.41	0.71	21.32	0.53	16.14
6	Eggs and egg product		0.09	2.70	0.10	2.75	0.08	2.38	0.11	2.86	0.11	2.86	0.09	2.83	0.08	2.53	0.09	2.63	0.07	2.06
7	Fish, seafood, amphibians, reptiles and invertebrates		1.31	37.57	1.26	35.65	1.57	48.84	1.35	36.62	1.34	35.37	1.44	45.91	1.27	38.58	1.19	35.96	1.66	50.91
9	Fruit and fruit products		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Fruit and vegetable juices and nectars		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Grains and grain-based products		0.31	8.80	0.32	9.13	0.22	6.85	0.28	7.68	0.30	8.07	0.15	4.81	0.33	9.97	0.34	10.33	0.27	8.29
12	Legumes, nuts, oilseeds and spices		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	Meat and meat products		0.47	13.34	0.49	13.96	0.31	9.75	0.57	15.46	0.60	15.79	0.41	12.98	0.37	11.13	0.39	11.91	0.24	7.46
14	Milk and dairy products		0.44	12.64	0.45	12.70	0.39	12.32	0.41	11.22	0.43	11.30	0.33	10.61	0.47	14.13	0.47	14.26	0.44	13.53
15	Products for non-standard diets, food imitates and food supplements or fortifying agents		0.02	0.48	0.02	0.54	0.00	0.13	0.01	0.20	0.01	0.22	0.00	0.00	0.03	0.77	0.03	0.89	0.01	0.21
16	Seasoning, sauces and condiments		0.00	0.07	0.00	0.08	0.00	0.03	0.00	0.09	0.00	0.10	0.00	0.04	0.00	0.06	0.00	0.07	0.00	0.02
17	Starchy roots or tubers and products thereof, sugar plants		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	Sugar, confectionery and water-based sweet desserts		0.03	0.93	0.04	1.05	0.01	0.27	0.04	0.99	0.04	1.08	0.01	0.31	0.03	0.88	0.03	1.01	0.01	0.23
19	Vegetables and vegetable products		0.03	0.77	0.03	0.86	0.01	0.25	0.03	0.69	0.03	0.76	0.00	0.12	0.03	0.87	0.03	0.97	0.01	0.35
20	Water and water-based beverages		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Mean Intake (µg/day)	3.49		3.54		3.20		3.69		3.78		3.13		3.30		3.31		3.26	
		P25 (µg/day)	1.21		1.27		0.96		1.32		1.38		1.06		1.12		1.19		0.88	
		P50 (µg/day)	2.16		2.26		1.68		2.40		2.47		2.01		1.94		2.04		1.45	
		P75 (µg/day)	4.10		4.18		3.39		4.34		4.47		3.94		3.85		3.95		3.21	
		P95 (µg/day)	10.96		10.91		11.66		11.07		11.09		9.27		10.43		10.06		12.09	
		% of EAR (P50)	21.6		22.6		16.8		24.0		24.7		20.1		19.4		20.4		14.5	
		% of persons above the EAR	5.70		5.70		5.70		6.10		6.30		4.70		5.20		5.00		6.20	

EAR - Estimated average requirement, 10 µg/day (IoM, 2011).

Table 4
Contribution of each TDS sample to vitamin D intake by food group for 'male and female', 'male' and 'female' age groups of the overall population.

FoodEx2 Food Group Nr	FoodEx2 Level 1 Food Group	TDS Sample	Male and Female																	
			18-74						18-64						65-74					
			Contribution (%)	Mean	P25	P50	P75	P95	Contribution (%)	Mean	P25	P50	P75	P95	Contribution (%)	Mean	P25	P50	P75	P95
				µg/day						µg/day						µg/day				
2	Alcoholic beverages	Beer	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
2		Wine	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
3	Animal and vegetable fats and oils	Butter	0.72	0.0250	0.0000	0.0000	0.0350	0.1120	0.68	0.0240	0.0000	0.0000	0.0280	0.1120	0.94	0.0301	0.0000	0.0000	0.0350	0.1400
3		Olive oils	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
4	Coffee, cacao and tea and infusions	Cocoa ingredients	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
4		Coffee beverages	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
4		Herbal and other non-tea infusions	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
4		Tea infusion (black, white)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5	Composite dishes	Beans and meat meal (Beans and gut dish)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Beans, meat, and vegetables meal 1 (Meat and vegetables boiled dish, Portuguese style)	0.33	0.0117	0.0000	0.0000	0.0000	0.0000	0.35	0.0124	0.0000	0.0000	0.0000	0.0000	0.25	0.0079	0.0000	0.0000	0.0000	0.0000
5		Beans, meat, and vegetables meal 2 (Beans stewed with pork and cow meat)	0.49	0.0171	0.0000	0.0000	0.0000	0.0000	0.49	0.0172	0.0000	0.0000	0.0000	0.0000	0.53	0.0169	0.0000	0.0000	0.0000	0.0000
5		Beans, meat, and vegetables meal 3 (Pork mest, chickpea, pasta and vegetables stewed)	0.08	0.0028	0.0000	0.0000	0.0000	0.0000	0.08	0.0029	0.0000	0.0000	0.0000	0.0000	0.06	0.0021	0.0000	0.0000	0.0000	0.0000
5		Dishes, incl. Ready to eat meals (excluding soups and salads) (Bread based Dish)	0.43	0.0149	0.0000	0.0000	0.0000	0.0000	0.36	0.0128	0.0000	0.0000	0.0000	0.0000	0.82	0.0262	0.0000	0.0000	0.0000	0.0000
5		Finger food	0.36	0.0124	0.0000	0.0000	0.0000	0.0000	0.39	0.0139	0.0000	0.0000	0.0000	0.0980	0.15	0.0048	0.0000	0.0000	0.0000	0.0000
5		Fish and potatoes meal (Cod fish dishes)	4.01	0.1399	0.0000	0.0000	0.0000	0.0000	4.13	0.1463	0.0000	0.0000	0.0000	0.0000	3.30	0.1057	0.0000	0.0000	0.0000	0.0000
5		Fish and potatoes meal (Mixed fish stew)	0.31	0.0110	0.0000	0.0000	0.0000	0.0000	0.26	0.0093	0.0000	0.0000	0.0000	0.0000	0.61	0.0197	0.0000	0.0000	0.0000	0.0000
5		Fish and potatoes meal (Potato puree with fish)	0.42	0.0145	0.0000	0.0000	0.0000	0.0000	0.45	0.0160	0.0000	0.0000	0.0000	0.0000	0.22	0.0069	0.0000	0.0000	0.0000	0.0000
5		Fish and rice meal	6.12	0.2134	0.0000	0.0000	0.0000	0.0000	6.08	0.2155	0.0000	0.0000	0.0000	0.0000	6.33	0.2027	0.0000	0.0000	0.0000	0.0000
5		Fish and seafood based dishes	2.39	0.0835	0.0000	0.0000	0.0000	0.0000	2.65	0.0938	0.0000	0.0000	0.0000	0.0000	0.90	0.0289	0.0000	0.0000	0.0000	0.0000
5		Fish soup	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Lasagna	0.25	0.0087	0.0000	0.0000	0.0000	0.0000	0.28	0.0099	0.0000	0.0000	0.0000	0.0000	0.06	0.0018	0.0000	0.0000	0.0000	0.0000
5		Legume (beans) soup	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Meat balls	0.19	0.0067	0.0000	0.0000	0.0000	0.0000	0.22	0.0078	0.0000	0.0000	0.0000	0.0000	0.02	0.0007	0.0000	0.0000	0.0000	0.0000
5		Meat based dishes	0.50	0.0174	0.0000	0.0000	0.0000	0.0000	0.51	0.0181	0.0000	0.0000	0.0000	0.0000	0.43	0.0137	0.0000	0.0000	0.0000	0.0000
5		Meat burger (no sandwich)	0.43	0.0151	0.0000	0.0000	0.0000	0.0000	0.50	0.0176	0.0000	0.0000	0.0000	0.0000	0.06	0.0019	0.0000	0.0000	0.0000	0.0000
5		Meat soup, with pieces (Chicken soup)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Mixed vegetable salad (Tomato and lettuce salad)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Mixed vegetable salad (Russian salad)	0.02	0.0008	0.0000	0.0000	0.0000	0.0000	0.02	0.0008	0.0000	0.0000	0.0000	0.0000	0.02	0.0007	0.0000	0.0000	0.0000	0.0000
5		Mixed vegetables soup (Green cabbage soup)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Mixed vegetables soup, with puree or pieces	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Omelette, plain	3.39	0.1182	0.0000	0.0000	0.0000	0.0000	3.53	0.1252	0.0000	0.0000	0.0000	0.0000	2.52	0.0809	0.0000	0.0000	0.0000	0.0000
5		Pizza and pizza-like dishes	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Potato based dishes (mashed potatoes)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Potatoes and meat meal (Potato puree with meat)	0.55	0.0191	0.0000	0.0000	0.0000	0.0000	0.57	0.0203	0.0000	0.0000	0.0000	0.0000	0.39	0.0123	0.0000	0.0000	0.0000	0.0000
5		Prepared fish salad	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Quiche	1.04	0.0362	0.0000	0.0000	0.0000	0.0000	1.09	0.0387	0.0000	0.0000	0.0000	0.0000	0.72	0.0230	0.0000	0.0000	0.0000	0.0000
5		Rice and meat meal	0.39	0.0135	0.0000	0.0000	0.0000	0.0000	0.37	0.0131	0.0000	0.0000	0.0000	0.0000	0.48	0.0154	0.0000	0.0000	0.0000	0.0000
5		Rice and vegetables meal	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Rice based dishes cooked	0.11	0.0038	0.0000	0.0000	0.0000	0.0000	0.07	0.0026	0.0000	0.0000	0.0000	0.0000	0.32	0.0103	0.0000	0.0000	0.0000	0.0000
5		Sandwich with meat and vegetable topping/filling	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
5		Seafood-based meals	0.17	0.0058	0.0000	0.0000	0.0000	0.0000	0.18	0.0065	0.0000	0.0000	0.0000	0.0000	0.08	0.0024	0.0000	0.0000	0.0000	0.0000
5		Tomato soup	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000

(*continued on next page*)

Table 4 (*continued*)

FoodEx2 Food Group Nr	FoodEx2 Level 1 Food Group	TDS Sample	Male and Female																	
			18-74						18-64						65-74					
			Contribution (%)	Mean	P25	P50	P75	P95	Contribution (%)	Mean	P25	P50	P75	P95	Contribution (%)	Mean	P25	P50	P75	P95
				µg/day						µg/day						µg/day				
6	Eggs and egg product	Hen eggs	2.70	0.0941	0.0000	0.0000	0.0000	0.6164	2.75	0.0975	0.0000	0.0000	0.0000	0.6164	2.38	0.0762	0.0000	0.0000	0.0000	0.5896
7	Fish, seafood, amphibians, reptiles and invertebrates	Atlantic salmon	2.52	0.0880	0.0000	0.0000	0.0000	0.0000	2.80	0.0991	0.0000	0.0000	0.0000	0.0000	0.91	0.0292	0.0000	0.0000	0.0000	0.0000
7		Bivalve molluscs	0.07	0.0024	0.0000	0.0000	0.0000	0.0000	0.05	0.0018	0.0000	0.0000	0.0000	0.0000	0.17	0.0054	0.0000	0.0000	0.0000	0.0000
7		Canned fish in oil 1 (Tuna)	1.26	0.0440	0.0000	0.0000	0.0000	0.0000	0.42	0.0149	0.0000	0.0000	0.0000	0.0000	0.62	0.0198	0.0000	0.0000	0.0000	0.0000
7		Canned fish in oil 2 (Sardine)	0.45	0.0157	0.0000	0.0000	0.0000	0.0000	1.38	0.0490	0.0000	0.0000	0.0000	0.0000	0.55	0.0175	0.0000	0.0000	0.0000	0.0000
7		Catfishes (freshwater)	0.22	0.0077	0.0000	0.0000	0.0000	0.0000	0.20	0.0070	0.0000	0.0000	0.0000	0.0000	0.35	0.0113	0.0000	0.0000	0.0000	0.0000
7		Cod, atlantic	0.05	0.0016	0.0000	0.0000	0.0000	0.0000	0.05	0.0019	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
7		Cod, dried	2.81	0.0980	0.0000	0.0000	0.0000	0.7980	2.54	0.0900	0.0000	0.0000	0.0000	0.7980	4.38	0.1405	0.0000	0.0000	0.0000	1.0080
7		Conger European	0.25	0.0087	0.0000	0.0000	0.0000	0.0000	0.19	0.0069	0.0000	0.0000	0.0000	0.0000	0.56	0.0181	0.0000	0.0000	0.0000	0.0000
7		European Sardine	4.82	0.1682	0.0000	0.0000	0.0000	0.0000	4.56	0.1617	0.0000	0.0000	0.0000	0.0000	6.33	0.2028	0.0000	0.0000	0.0000	0.0000
7		Fish fingers, breaded	0.44	0.0154	0.0000	0.0000	0.0000	0.0000	0.51	0.0180	0.0000	0.0000	0.0000	0.0000	0.05	0.0016	0.0000	0.0000	0.0000	0.0000
7		Hakes	1.43	0.0498	0.0000	0.0000	0.0000	0.4727	1.43	0.0505	0.0000	0.0000	0.0000	0.4727	1.44	0.0462	0.0000	0.0000	0.0000	0.4727
7		Horse mackerel	1.58	0.0551	0.0000	0.0000	0.0000	0.0000	1.34	0.0475	0.0000	0.0000	0.0000	0.0000	2.99	0.0957	0.0000	0.0000	0.0000	0.0000
7		Ling	0.13	0.0047	0.0000	0.0000	0.0000	0.0000	0.08	0.0028	0.0000	0.0000	0.0000	0.0000	0.44	0.0142	0.0000	0.0000	0.0000	0.0000
7		Mackerel, chub	0.45	0.0157	0.0000	0.0000	0.0000	0.0000	0.32	0.0115	0.0000	0.0000	0.0000	0.0000	1.19	0.0380	0.0000	0.0000	0.0000	0.0000
7		Marine shrimps or prawns, cooked	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
7		Nile perch	0.85	0.0295	0.0000	0.0000	0.0000	0.0000	0.79	0.0281	0.0000	0.0000	0.0000	0.0000	1.15	0.0367	0.0000	0.0000	0.0000	0.0000
7		Octopus, common	0.53	0.0185	0.0000	0.0000	0.0000	0.0000	0.56	0.0200	0.0000	0.0000	0.0000	0.0000	0.34	0.0108	0.0000	0.0000	0.0000	0.0000
7		Other coastal marine fishes (wrasse, pouting, blackspot seabream, red porgy)	3.96	0.1383	0.0000	0.0000	0.0000	0.0000	3.76	0.1331	0.0000	0.0000	0.0000	0.0000	5.17	0.1656	0.0000	0.0000	0.0000	0.0000
7		Other pelagic marine fishes 1 (forkbeard, red fish)	0.84	0.0295	0.0000	0.0000	0.0000	0.0000	1.12	0.0399	0.0000	0.0000	0.0000	0.0000	1.80	0.0577	0.0000	0.0000	0.0000	0.0000
7		Other pelagic marine fishes 2 (Swordfish)	1.22	0.0427	0.0000	0.0000	0.0000	0.0000	0.83	0.0294	0.0000	0.0000	0.0000	0.0000	0.93	0.0298	0.0000	0.0000	0.0000	0.0000
7		Plaice, european	6.13	0.2139	0.0000	0.0000	0.0000	0.0000	5.71	0.2022	0.0000	0.0000	0.0000	0.0000	8.60	0.2757	0.0000	0.0000	0.0000	0.0000
7		Sea Bream	4.90	0.1709	0.0000	0.0000	0.0000	0.0000	4.16	0.1473	0.0000	0.0000	0.0000	0.0000	9.24	0.2962	0.0000	0.0000	0.0000	0.0000
7		Squid, common	1.51	0.0527	0.0000	0.0000	0.0000	0.0000	1.64	0.0583	0.0000	0.0000	0.0000	0.0000	0.72	0.0230	0.0000	0.0000	0.0000	0.0000
7		Terrestrial snails, edible	0.49	0.0171	0.0000	0.0000	0.0000	0.0000	0.57	0.0204	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
7		Tuna	0.66	0.0231	0.0000	0.0000	0.0000	0.0000	0.62	0.0219	0.0000	0.0000	0.0000	0.0000	0.91	0.0291	0.0000	0.0000	0.0000	0.0000
9	Fruit and fruit products	Apple	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Banana	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Canned or jarred fruit	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Dried figs	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Dried vine fruits (raisins etc.)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Fruit salad	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Jam	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Kiwifruit	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Orange,sweet	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Peach	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Pear	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Pineapple	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Strawberry	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
9		Table-grapes	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000

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Table 4 (*continued*)

FoodEx2 Food Group Nr	FoodEx2 Level 1 Food Group	TDS Sample	Male and Female																	
			18-74						18-64						65-74					
			Contribution (%)	Mean	P25	P50	P75	P95	Contribution (%)	Mean	P25	P50	P75	P95	Contribution (%)	Mean	P25	P50	P75	P95
				mg/kg bw/day						mg/kg bw/day						mg/kg bw/day				
10	Fruit and vegetable juices and nectars	Fruit juices	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
10		Fruit nectar	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
11	Grains and grain-based products	Biscuits, chocolate	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.3236	0.0000	0.0000	0.0000	0.0000	0.00	0.2196	0.0000	0.0000	0.0000	0.0000
11		Biscuits, sweet, plain	0.75	0.0260	0.0000	0.0000	0.0000	0.1440	0.73	0.0000	0.0000	0.0000	0.0000	0.1200	0.85	0.0000	0.0000	0.0000	0.0000	0.1500
11		Cakes	0.09	0.0030	0.0000	0.0000	0.0000	0.0000	0.08	0.0000	0.0000	0.0000	0.0000	0.0000	0.09	0.0000	0.0000	0.0000	0.0000	0.0000
11		Chocolate cakes	1.10	0.0382	0.0000	0.0000	0.0000	0.0000	1.24	0.0000	0.0000	0.0000	0.0000	0.0000	0.26	0.0000	0.0000	0.0000	0.0000	0.0000
11		Crackers	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
11		Croissant	0.07	0.0025	0.0000	0.0000	0.0000	0.0000	0.08	0.0000	0.0000	0.0000	0.0000	0.0088	0.02	0.0000	0.0000	0.0000	0.0000	0.0000
11		Flan tart	0.13	0.0047	0.0000	0.0000	0.0000	0.0000	0.14	0.0000	0.0000	0.0000	0.0000	0.0000	0.10	0.0000	0.0000	0.0000	0.0000	0.0000
11		Fruit cake	0.64	0.0223	0.0000	0.0000	0.0000	0.0000	0.49	0.0000	0.0000	0.0000	0.0000	0.0000	1.50	0.0000	0.0000	0.0000	0.0000	0.0000
11		Fruit pie-tarts	0.16	0.0055	0.0000	0.0000	0.0000	0.0000	0.16	0.0000	0.0000	0.0000	0.0000	0.0000	0.13	0.0000	0.0000	0.0000	0.0000	0.0000
11		Muffins	0.21	0.0075	0.0000	0.0000	0.0000	0.0000	0.23	0.0000	0.0000	0.0000	0.0000	0.0000	0.14	0.0000	0.0000	0.0000	0.0000	0.0000
11		Pasta and similar products	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
11		Popcorn (maize, popped)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
11		Processed and mixed breakfast cereals	4.74	0.1656	0.0000	0.0000	0.0000	1.1760	5.13	0.0000	0.0000	0.0000	0.0000	1.1760	2.46	0.0000	0.0000	0.0000	0.0000	0.5880
11		Rice grains (p)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
11		Shortcrust (pies -tarts)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
11		Single grain bread and rolls	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
11		Sponge cake	0.30	0.0106	0.0000	0.0000	0.0000	0.0000	0.28	0.0000	0.0000	0.0000	0.0000	0.0000	0.45	0.0000	0.0000	0.0000	0.0000	0.0000
11		Various pastry	0.25	0.0086	0.0000	0.0000	0.0000	0.0000	0.25	0.0000	0.0000	0.0000	0.0000	0.0000	0.23	0.0000	0.0000	0.0000	0.0000	0.0000
11		Wheat bread and rolls, white (refined flour)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
11		Yeast leavened pastry 1 (leavened cake)	0.04	0.0015	0.0000	0.0000	0.0000	0.0000	0.04	0.0000	0.0000	0.0000	0.0000	0.0000	0.05	0.0000	0.0000	0.0000	0.0000	0.0000
11		Yeast leavened pastry 2 (brioche)	0.32	0.0111	0.0000	0.0000	0.0000	0.0000	0.27	0.0000	0.0000	0.0000	0.0000	0.0000	0.60	0.0000	0.0000	0.0000	0.0000	0.0000
12	Legumes, nuts, oilseeds and spices	Beans (dry seeds)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
12		Broad bean (fresh seeds)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
12		Chick-pea (dry seeds)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
12		Cowpea (dry seeds)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
12		Lupin (dry seeds)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
12		Peanut	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
12		Peas (fresh seeds, without pods)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
12		Table olives for consumption	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
13	Meat and meat products	Bovine fresh meat	3.69	0.1288	0.0000	0.0000	0.0000	0.8460	3.85	0.4946	0.0000	0.0000	0.0000	0.8460	2.77	0.3123	0.0000	0.0000	0.0000	0.5400
13		Calf fresh meat	0.06	0.0021	0.0000	0.0000	0.0000	0.0000	0.06	0.0000	0.0000	0.0000	0.0000	0.0000	0.06	0.0000	0.0000	0.0000	0.0000	0.0000
13		Chicken fresh meat	4.52	0.1576	0.0000	0.0000	0.0000	1.0380	4.82	0.0000	0.0000	0.0000	0.0000	1.0380	2.73	0.0000	0.0000	0.0000	0.0000	0.6420
13		Cooked cured meat (cooked ham)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
13		Dry and fermented sausages	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
13		Frankfurter type sausage	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
13		Rabbit fresh meat	0.17	0.0060	0.0000	0.0000	0.0000	0.0000	0.17	0.0000	0.0000	0.0000	0.0000	0.0000	0.19	0.0000	0.0000	0.0000	0.0000	0.0000
13		Raw cured meat (ham and bacon)	0.36	0.0125	0.0000	0.0000	0.0000	0.0000	0.36	0.0000	0.0000	0.0000	0.0000	0.0000	0.36	0.0000	0.0000	0.0000	0.0000	0.0000
13		Sheep fresh meat	0.17	0.0058	0.0000	0.0000	0.0000	0.0000	0.16	0.0000	0.0000	0.0000	0.0000	0.0000	0.23	0.0000	0.0000	0.0000	0.0000	0.0000
13		Swine fresh meat	4.08	0.1423	0.0000	0.0000	0.0000	1.1200	4.22	0.0000	0.0000	0.0000	0.0000	1.1200	3.23	0.0000	0.0000	0.0000	0.0000	0.9310
13		Turkey fresh meat	0.30	0.0105	0.0000	0.0000	0.0000	0.0000	0.32	0.0000	0.0000	0.0000	0.0000	0.0000	0.19	0.0000	0.0000	0.0000	0.0000	0.0000

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Table 4 (*continued*)

FoodEx2 Food Group Nr	FoodEx2 Level 1 Food Group	TDS Sample	Male and Female																	
			18-74						18-64						65-74					
			Contribution	Mean	P25	P50	P75	P95	Contribution	Mean	P25	P50	P75	P95	Contribution	Mean	P25	P50	P75	P95
			(%)	mg/kg bw/day					(%)	mg/kg bw/day					(%)	mg/kg bw/day				
14	Milk and dairy products	Acidophilus milk	0.22	0.0078	0.0000	0.0000	0.0000	0.0000	0.23	0.4499	0.0000	0.0000	0.0000	0.0000	0.22	0.3948	0.0000	0.0000	0.0000	0.0000
14		Cow milk	4.96	0.1730	0.0000	0.1580	0.2370	0.5135	4.87	0.0000	0.0000	0.1548	0.2370	0.5186	5.51	0.0000	0.0000	0.1620	0.2370	0.4780
14		Dairy desserts spoonable	2.51	0.0877	0.0000	0.0000	0.0000	0.0000	2.44	0.0000	0.0000	0.0000	0.0000	0.0000	2.92	0.0000	0.0000	0.0000	0.0000	0.0000
14		Firm - ripened cheeses	1.86	0.0649	0.0000	0.0000	0.1056	0.3504	1.91	0.0000	0.0000	0.0000	0.1056	0.3504	1.56	0.0000	0.0000	0.0000	0.0000	0.2736
14		Flavoured milks	0.37	0.0129	0.0000	0.0000	0.0000	0.0000	0.41	0.0000	0.0000	0.0000	0.0000	0.0330	0.10	0.0000	0.0000	0.0000	0.0000	0.0000
14		Yoghurt	2.72	0.0948	0.0000	0.0000	0.0000	0.4400	2.84	0.0000	0.0000	0.0000	0.0000	0.4400	2.01	0.0000	0.0000	0.0000	0.0000	0.3960
15	Products for non-standard diets, food	Meat imitates	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0191	0.0000	0.0000	0.0000	0.0000	0.00	0.0040	0.0000	0.0000	0.0000	0.0000
15		Soya drink	0.48	0.0167	0.0000	0.0000	0.0000	0.0000	0.54	0.0000	0.0000	0.0000	0.0000	0.0000	0.13	0.0000	0.0000	0.0000	0.0000	0.0000
16	Seasoning, sauces and condiments	Mayonnaise	0.07	0.0026	0.0000	0.0000	0.0000	0.0000	0.08	0.0029	0.0000	0.0000	0.0000	0.0000	0.03	0.0009	0.0000	0.0000	0.0000	0.0000
16		Other common table-top condiments	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
16		Stock cubes or granulate, meat	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
16		Tomato ketchup	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
16		Vinegar	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
17	Starchy roots or tubers	Potato boiled	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
18	Sugar, confectionery and water-based sweet desserts	Chocolate and chocolate products	0.93	0.0325	0.0000	0.0000	0.0000	0.0900	1.05	0.0371	0.0000	0.0000	0.0000	0.1200	0.27	0.0085	0.0000	0.0000	0.0000	0.0000
18		Gelatine dessert	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
18		White sugar	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19	Vegetables and vegetable products	Asparagus	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0306	0.0000	0.0000	0.0000	0.0000	0.00	0.0081	0.0000	0.0000	0.0000	0.0000
19		Beans, green with pods	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Broccoli	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Brussels sprouts	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Carrot	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Cauliflower	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Common melon varieties	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Common/portobello/champignon mushroom	0.77	0.0270	0.0000	0.0000	0.0000	0.0000	0.86	0.0000	0.0000	0.0000	0.0000	0.0000	0.25	0.0000	0.0000	0.0000	0.0000	0.0000
19		Lettuce	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Melons (except watermelon)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Onion Bulb	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Other leafy vegetables (Rapini)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Peppers, sweet	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Portugese cabbage	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Sweet corn canned	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Tomato and similar (p)	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Turnip greens	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		Watermelon	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
19		White cabbage	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
20	Water and water-based beverages	Cola beverages, caffeinic	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
20		Soft drink, mixed flavours	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
20		Soft drink, orange flavour	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
20		Still natural mineral water	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000
			100.00	3.4895	0.0000	0.1580	0.3776	7.7170	100.00	3.5434	0.0000	0.1548	0.3706	7.8679	100.00	3.2042	0.0000	0.1620	0.2720	6.2089

Table 5
Top five contributors to vitamin D total intake (number-order by contribution to intake, 1-most contributor).

Age group	18–74			18–64			65–74		
Sex	MF	F	M	MF	F	M	MF	F	M
Plaice	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**3**	**1**
Gilt-head seabream	**2**	**2**	8	**5**	**3**	6	**1**	**1**	–
Sardine	**3**	**4**	**2**	**2**	6	**1**	**3**	**2**	**4**
Octopus rice	**4**	**5**	**3**	**3**	**5**	**3**	**5**	6	**3**
Semi-skimmed milk	**5**	**3**	**5**	**4**	**2**	**5**	**4**	**4**	**3**
Chicken	7	8	**4**	6	7	**4**	12	18	7
Breakfast cereals	9	6	13	8	**4**	11	11	11	28
Leite-creme(custard)	14	10	16	13	12	16	8	**5**	19
Codfish (salted, soaked)	11	13	9	12	14	13	6	8	**2**

M-males; F-females.

the adult population (age 19–64 years) with vitamin D intake below the EAR, whereas nine countries ranged between 33.0 and 100% for elderly and very elderly (age > 64 years). Concerning mean intakes, the same population groups and countries presented values varying between 1.2 and 10.9 μg/day for adults and 0.7–15 μg/day for elderly and very elderly. Finland and Norway, presented the best results; however, food supplements were included in the Norwegian survey.

In the TDS conducted in Czechia in 2014–2015, the median intake of vitamin D for adults (18–64 years old) was 3.9 μg/day and 2.8 μg/day, for males and females, respectively. For the elderly and very elderly (≥65 years old) the median intake was 3.5 and 3.1 μg/day, for males and females, respectively (Bischofova et al., 2018). More recently, in an evaluation based on the EU Menu Methodology, the vitamin D mean intake in Slovenia was 2.9 μg/day for adults (18–64 years old) and 2.5 μg/day for elderly (65–74 years old). A difference between sexes was observed for adults, with higher intake by males (Hribar et al., 2021).

A EFSA's scientific opinion (EFSA, 2012) summarised vitamin D intake results from studies of different countries (2002–2011) using different dietary assessment methods and showed, for adults and elderly (different age subgroups), mean dietary intakes (excluding supplements) between 1.1 and 6.1 μg/day for women and 1.5–8.2 μg/day for man.

The six major food groups contributing to vitamin D intake by the Portuguese 'overall population' were 'Fish, seafood, amphibians, reptiles and invertebrates' (38%); 'Composite dishes' (22%); 'Meat and meat products' (13%); 'Milk and dairy products' (13%); 'Grains and grain-based products (fortified)' (8.8%), 'Eggs and egg products' (2.7%) (Table 3). No substantial differences were observed among age groups and sexes, except for the 'elderly', where 'Fish, seafood, amphibians, reptiles and invertebrates' contributed between 46–51% and, 'Composite dishes', 'Meat and meat products' and 'Grains and grain-based products' showed a lower contribution.

The main contributors found in Czechia were 'hen eggs' (21%), 'fine bakery wares' (11%), 'cow's milk and dairy products' (7%), 'margarines' (7%), 'fish' (6%) and 'meat and meat products' (4%) (Bischofova et al., 2018), whereas, for the Slovenian adult population the main contributors were 'eggs' (~20%), 'beef, veal and pork meat' (~20%), 'sea fish' (~15%), 'fish cans and pates' (~11%), 'sausages, hot dogs and meat pate' (~8%), 'cheese and cheese spreads' (~5%) (Hribar et al., 2021). These results reflect different food habits, and evidence the importance of performing these studies in different countries and of harmonising food classification.

The contribution of each food as measured (TDS sample) to the total vitamin D intake of the 'male' and 'female' population by age group is presented in Table 4. Data for 'male' and 'female' populations by age group is provided in supplementary information (supplementary information Table S1).

To evaluate the contribution of each food as eaten to the intake of vitamin D, the content of each TDS sample was assigned to all its composing subsamples. Regarding 'overall population', it was observed that 47.3% of the intake was provided by 262 of 277 foods containing vitamin D, each one contributing to less than 2%. The top five contributors, considering all age and sex groups, belonged to a list of nine foods: plaice, sea bream, European sardine, octopus rice, semi-skimmed milk, chicken, breakfast cereals (fortified), *leite-creme* (a kind of custard) and codfish (salted, soaked) (Table 5).

The important contribution of fish to vitamin D intake is in line with the high consumption of fish and seafood, in Portugal, the second European largest consumer, with the mean of 41.8 g/day and the median of 37.0 g/day (edible part) (Lopes et al., 2018), after Iceland, and the third in the world (estimates based on per capita food supply) (Statista, 2022).

The vitamin D intake by 'overall population' estimated by this TDS was lower than the one obtained in the Portuguese National Food, Nutrition and Physical Activity Survey (IAN-AF) (Lopes et al., 2018), median 2.2 vs. 3.7 μg/day, mean 3.5 vs. 5.6 μg/day. However, both studies indicate a vitamin D intake much lower than the Dietary Reference Value. The differences found may be influenced by several factors. The TDS used an older consumption survey (2009) than the IAN-AF (2015–2016) and used one-day instead of two days 24 h recall. Furthermore, the IAN-AF consumption survey included food supplements. Also, IAN-AF used the Portuguese Food Composition Table as source of nutrient values whereas in TDS the nutrient content of the TDS samples was determined analytically, and a dilution effect may occur because each analysed sample was composed of 12 sub-samples; nevertheless, this effect was apparently not important in the case of vitamin D because the analytical detection limit was very low.

4. Conclusions

According to the present study, considering diet (excluding dietary supplements) as the unique vitamin D source, the prevalence of inadequacy of vitamin D intake, for adult and elderly Portuguese population, was estimated to be around 94%, considering the estimated average requirement of 10 μg/day. No appreciable difference was found between groups both by age ('adult' and 'elderly') and sex. Based on this research focused on diet, special attention should be taken to the general population during months near the winter solstice and to people living indoors, to prevent vitamin D low status. The importance of the dietary intake is evidenced when UVB does not reach the skin with adequate intensity to induce vitamin D synthesis.

These findings suggest the need for the implementation of policies defining food-based strategies to improve the health status related to vitamin D of the homebound, institutionalized, indoors working, long-term hospitalized Portuguese population.

Based on the present evaluation, the risk of chronic excessive intake is out of concern, since 100% of the Portuguese population ingests less than 72% of the 100 μg/day Tolerable Upper Intake Level established by EFSA (intake through supplements not taken into account).

CRediT authorship contribution statement

M. Graça Dias: Conceptualization, Investigation, Formal analysis,

Writing – original draft, Visualization. **Elsa Vasco:** Conceptualization, Writing – review & editing. **Francisco Ravasco:** Investigation. **Luísa Oliveira:** Conceptualization, Funding acquisition, Project administration, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodchem.2023.136676.

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