



## CHALLENGES FOR FORTIFIED FOODS REACHING DAILY VITAMIN D REQUIREMENTS

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Currently, over 2 billion individuals worldwide experience micronutrient deficiencies primarily due to a lack of essential vitamins and minerals in their diet. Micronutrient malnutrition among preschool-aged children and non-pregnant women of reproductive age is a significant public health concern that impacts populations across the globe, including those in high-income nations. Widespread implementation of food fortification with micronutrients strives to mitigate micronutrient deficiencies and associated adverse effects. The worldwide occurrence and population affected by vitamin deficiencies have not been accurately measured. This is mostly because many cases of micronutrient deficiencies go untreated as a result of ambiguous and non-specific symptoms, which is why it is sometimes referred to as hidden hunger. Furthermore, population-based surveys often lack the inclusion of biomarkers for assessing micronutrient status. This omission has resulted in a significant lack of knowledge regarding the extent of micronutrient deficiency at both national and global levels. Vitamin-enriched foods and/or vitamin supplements are beneficial in this situation to remedy insufficiency or deficiency. Nevertheless, the extent to which consumers comprehend their nutritional status and employ these products effectively remains ambiguous. The term “food fortification” refers to the process of supplementing commonly ingested foods with vitamins and minerals in an effort to increase their nutritional value. Vitamin D is getting more attention because many new studies show that, in addition to its well-known effects on bone metabolism and immunity, low vitamin D levels are linked to a lower risk of getting many diseases, such as cancers, cardiovascular diseases, and neurodegenerative diseases. The study aims to examine the presence of fortified products in the domestic market, explore the level of awareness among Romanian consumers regarding fortified meals, and assess the extent to which accessible fortified foods meet the vitamin D requirement. The results of this research indicate that vitamin D-fortified foods are widely available on the national market, particularly in margarine, dairy products, and soy-based goods. The amount of added vitamin D varies between 7.5% of the reference nutritional value in plant-based drinks and 56% of the RDI in margarines and oils. The contribution of these foods to covering the daily requirement of vitamin D is minor.

*Keywords:* fortified foods, vitamin D, nutrients deficiency

### INTRODUCTION

Research, recent systematic review and meta-analysis of large-scale food fortification (LSFF) programs<sup>1</sup>, has confirmed the impact of fortification on nutritional outcomes in low- and middle-income countries, including reductions in goiter and neural tube defects (NTDs) among children; improvements in serum folate levels among women of reproductive age; and decreases in instances of vitamin A deficiency, iodine deficiency, anemia, and iron deficiency among women and children<sup>2,3</sup>.

The dietary requirement for a particular micronutrient is the level at which it is considered sufficient to limit the risk of both a deficiency or an excessive intake of the nutrient. Individuals<sup>4</sup> nutrient requirements differ based on several characteristics such as age, gender, and physical activity levels, and can be elevated during periods of pregnancy, lactation, and illness. It is possible to utilize particular demand numbers that are tailored to their demographic profile. Another factor to consider when determining the need for vitamins

and minerals is caloric intake, as some vitamins (for example, vitamins B1, B6) are related to the number of calories consumed. The aetiology of infant micronutrient deficiencies is comprehensively documented. The deficiencies arise from one of the four scenarios outlined below<sup>4</sup>: (a) inadequate initial stores of micronutrients due to preterm birth, low birthweight, or micronutrient deficiency during pregnancy; (b) accelerated postnatal growth; (c) consumption of foods containing low concentrations of micronutrients; and (d) gastrointestinal pathology that causes malabsorption of nutrients, including micronutrients. It is critical to identify the root cause of the deficiencies in order to develop effective interventions for their prevention or treatment<sup>5</sup>. Several variables, such as poor food quality or quantity (hidden hunger)<sup>6</sup>, increased dietary requirements, larger metabolic losses, or impaired gastrointestinal digestion and absorption, can contribute to borderline or low nutritional status. “Nutritional inadequacy” refers to an insufficient intake of nutrients that falls below the estimated average requirement<sup>7</sup>. On the other hand, “nutritional deficiency” refers to significantly reduced levels of one or more nutrients, which impairs the body's ability to function properly and increases the risk of various diseases such as cancer, diabetes, and heart disease. In clinical approach, the levels of vitamins and minerals are usually determined by analysing biomarkers or observing signs and symptoms that are indicative of a clinical condition or nutrient shortage<sup>8</sup>. The global prevalence of vitamin D insufficiency is now acknowledged as a pandemic. The primary factor contributing to vitamin D shortage is the insufficient recognition that moderate sun exposure serves as the primary means of vitamin D acquisition for the majority of individuals. Many countries have low levels of vitamin D consumption and status, mostly because of variations in seasonal UVB exposure and the limited availability of foods that are naturally high in vitamin D. Evidence from data modelling research indicates that the consumption of vitamin D rises as a result of food fortification. Moreover, nations that enforce obligatory fortification laws have greater vitamin D intake and status in comparison to countries that do not. Vitamin D bioavailability varies based on fortification methods, food structure, and composition, despite the fact that numerous foods can be supplemented

with vitamin D. Only a small number of foods include vitamin D naturally, and foods that have vitamin D added to them are generally insufficient to meet the vitamin D needs of both children and adults. Insufficient levels of vitamin D lead to the development of rickets in children and can worsen and intensify osteopenia, osteoporosis, and fractures in adults.

## MATERIALS AND METHODS

An analysis of the national registry of fortified foods was conducted to find out the availability of fortified products in the Romanian market. When a vitamin or mineral is added to food, it must have that vitamin or mineral in it, at least in a significant amount, which means 15% from dietary value of reference (DVR) in solid food or 7,5%DVR in liquids<sup>9</sup>. In order to evaluate the contribution of fortified foods to cover the vitamin D requirement for each product, the amount of vitamin D was recorded as declared by the manufacturer on the label.

In order to assess the awareness about fortified foods, an online questionnaire with 20 items was created, and distributed to the 150 participants in the recreational activities of a club from Arad, Romania. The items included in addition, general information about gender, age, lifestyle, food choices, and questions regarding the knowledge of consumers regarding the addition of vitamins and minerals to the respective foods, to their use in food. The sample formed by those who chose to answer included 115 people. The sample size was calculated using OpenEpi, Version 3, open source calculator – SSPropor. For the number of participants, relative to the number of members of the target group, the results of the study can be considered statistically significant, with a confidence interval of 97%. Results from OpenEpi, Version 3, open source calculator—SSPropor. Sample size  $n = [DEFF * Np (1-p)] / [(d2/Z21 - \alpha/2 * (N-1) + p * (1-p))]$

## RESULTS

After analysing the items registered in the national registry of fortified foods, it was discovered that 676 of the 4600 notified products were vitamin D fortified (Figure 1).

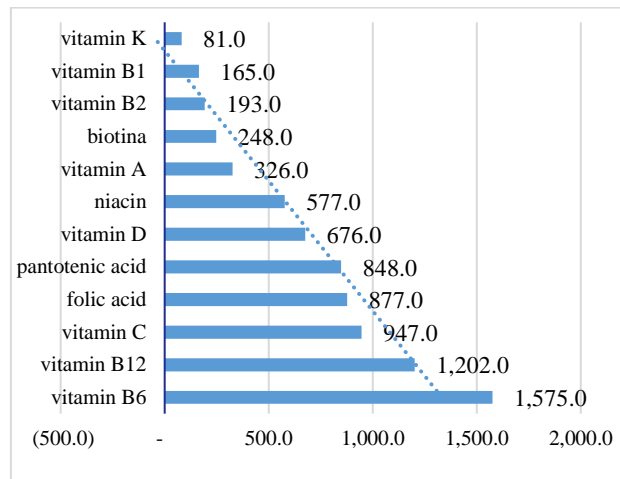


Figure 1. Number of fortified items categorised by vitamins in the national register.

Vitamin D-fortified foods are widely available on the national market, particularly in margarine, drinking yoghurt, and breakfast cereals. Figure 2

present the number of products found to be added with vitamin D, and the average amount *per* each food group.

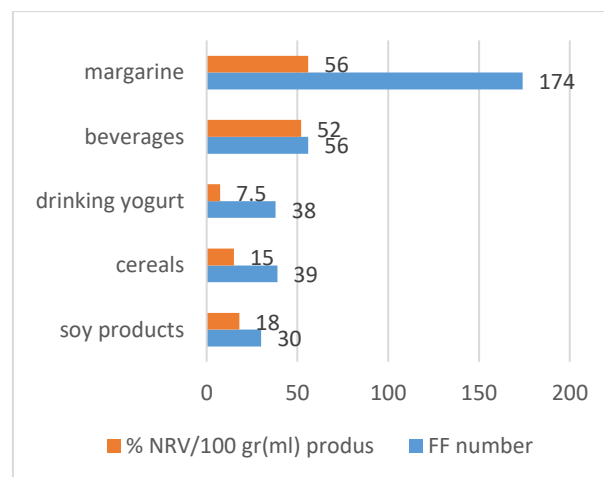


Figure 2. Evaluation of the amount of folic acid based on the number of fortified items included in the national registry and the percentage of the nutritional reference value.

The survey was filled out by subjects ranging in age from 19 to 65 years, sex ratio 1:3 male/female. Regarding their lifestyle, 71, 5 % of individuals see themselves as highly busy, prioritizing productivity over relaxation. In terms of nutrition, 59, 4 % of the population has a normal weight, 31, 2% are overweight, 4,1 % are obese, and 5,3 % are underweight. With regards to food choices, 54, 5 % of the participants value the inclusion of all food groups, 2,1 % have lactose sensitivity, 28,2% mostly consume meat and dairy products, and 10,6% primarily consume enough fruits and vegetables in their diet. Food is the source of vitamins and minerals for 58, 9 % of the respondents. In the spring and autumn, 28, 6 % choose to consume food supplements, while 14, 5

% consume food supplements after undergoing tests. Only 22, 5 % of participants choose foods based on their vitamin and mineral composition. With regards to the inclusion of vitamins and minerals, 6% of participants consider it unnecessary, 17, 3% believe it is essential in all foods to prevent deficiencies, and 27, 4% consider fortification important only in specific foods. Furthermore, 9, 6 % of the participants highlighted the matter of toxicity, finding it important to alert customers. 40, 8 % indicated their lack of awareness regarding the existence of fortified food. The study highlights a lack of information regarding fortified food among the adult population, despite their active lifestyle and motivation in maintaining a healthy lifestyle.

## DISCUSSIONS

Food fortification is a tried-and-true, secure, and economical method for enhancing dietary patterns and managing micronutrient insufficiencies. The effectiveness of food fortification in high income countries to address micronutrient deficiencies is supported by substantial evidence. Malnutrition may express itself in several forms: undernutrition, micronutrient-related malnutrition, and obesity<sup>10</sup>. Malnutrition caused by a lack of micronutrients or inadequate intake of iodine, vitamin A, and iron are the most significant in terms of global public health.

Obesity and overweight are caused by an imbalance between energy consumed (an excess) and energy expended (an insufficient amount). People worldwide are consuming more energy-dense foods and beverages (rich in sugars and fats) and engaging in less physical activity. According to the data published by OurWorldInData.org, in Romania nutritional deficiencies decreased from 0.77% of all cases of illness in 1990 to 0.44% in 2019. The inequality in per capita calorie intake in Romania also changes and in our day is the same as it is in developed countries, as we can see in Figure 3.

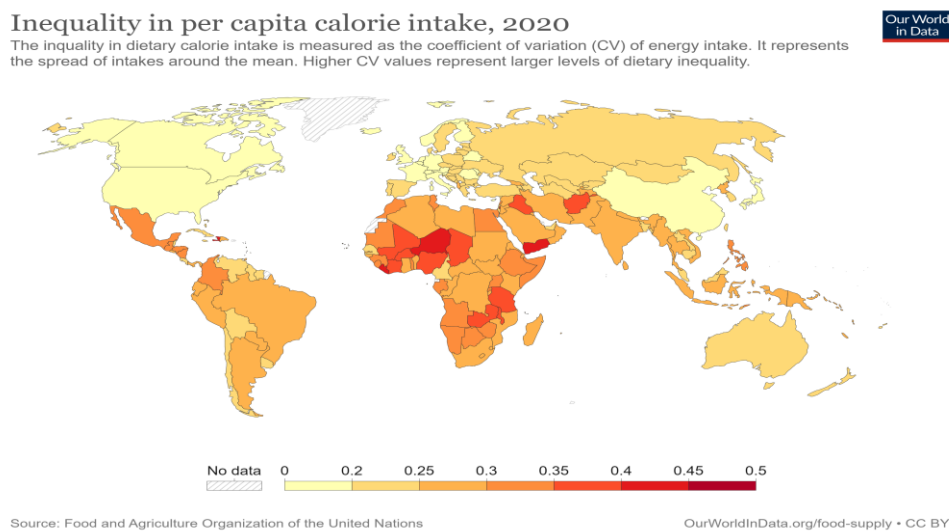


Figure 3. Map of inequality in per capita calorie intake.<sup>11</sup>

At the European level each product containing added vitamins, minerals, or other substances must be notified to the competent authority, which is in Romania the Ministry of Health, prior to its release on the national food market. The Ministry of Health delegate this responsibility to the Romanian National Public Health Institute. All notified products that satisfy the chemical form and added quantity requirements are recorded in the national register of fortified foods<sup>12</sup>. For vitamin D DRV is set to 5 µg for adults and the eligible chemical forms to be added are cholecalciferol and ergocalciferol. The upper limit (UL) for adults and adolescents has been increased in 2012 from 50µg to 100µg per day. Similarly, the UL for children aged 1–10 has been raised from 25µg to 50µg per day<sup>13</sup>. In 2018 a UL of 35 µg/day was established for infants 6–12 months<sup>14</sup>.

The current fortification of vitamin D is estimated to avert around 11,000 cancer deaths in the European Union and 27,000 cancer deaths in all

European countries annually<sup>15</sup>. Implementing appropriate vitamin D fortification of foods in all countries mentioned would prevent an estimated 129,000 cancer deaths (113,000 in the European Union). This would also result in the prevention of approximately 1.2 million years of life lost (1.0 million in the EU), which accounts for approximately 9% of cancer deaths (10% in the EU)<sup>16</sup>. Despite of this figures, variable public perceptions were found<sup>16</sup> for each vitamin, with biotin receiving the lowest rating (41.9%) and vitamin C receiving the highest (93.2%). Furthermore, it was found that only a fraction of the respondents claimed to consume adequate quantities of each vitamin; with vitamin C receiving the highest percentage (22.3%), and biotin the lowest (5.2%)<sup>19</sup>. Despite this, the majority of individuals refrained from consuming vitamin-fortified foods and/or supplements for financial constraints. The objectives of vitamin-fortified food and supplement consumers were diverse, including

nutrient supplementation (47.8%), beauty-related purposes (27.5%), infectious disease prevention (23.2%), and maintenance of health (80.5%). Improving consumer awareness and the environment are crucial for addressing nutritional deficiencies in individuals. This can encourage consumers to utilize acceptable vitamin products without experiencing undue hardship<sup>19</sup>.

Fortified foods are perceived as potential remedies for addressing public health concerns, including vitamin D deficiency. The present study identified the addition in significant amounts in margarines, plant-based drinks, drinking yogurt or breakfast cereals. Since the significant addition is related to 100 grams / millilitres of product to cover a significant proportion of the daily required amount of vitamin D, it would be necessary to ingest unreasonable amounts of these foods. Therefore, this type of food products have a modest contribution to the vitamin D requirement. Similar results have been reported in other studies. Following three decades of experience incorporating folic acid supplementation into foods, starter and follow-on formulations, and foods intended for the general population, several controversies were brought to light through a meta-analysis of published articles<sup>17</sup>. Randomized controlled studies indicate that the bioavailability of vitamin D<sub>2</sub> differs among various diets, but vitamin D<sub>3</sub> is bioavailable in numerous food sources<sup>18</sup>. Research conducted in laboratory settings indicates that modifying the lipid composition of fortified foods enhances the absorption of vitamin D<sub>3</sub><sup>19</sup>. Olive oil exhibited enhanced vitamin D<sub>3</sub> absorption during the process of *in vitro* digestion in comparison to other dietary oils<sup>20</sup>. Furthermore, the absorption of vitamin D<sub>3</sub> was enhanced when it was included in micelles generated from the *in vitro* digestion of olive oil, surpassing the absorption rates observed with other types of dietary oils. Nevertheless, in a study conducted on humans after a meal, it was found that a dairy drink containing preformed vitamin D<sub>3</sub> micelles did not lead to an increase in the absorption of vitamin D<sub>3</sub><sup>21</sup>. On the other hand, a dairy drink containing vitamin D<sub>3</sub> from olives just boosted the absorption of vitamin D<sub>3</sub>, but only in people who were lacking sufficient vitamin D(24). The vitamin D for adults <50 years, the four studies involving calcium or vitamin D showed a beneficial effect on bone remodeling. For adults ≥50 years, n=14 provided calcium and/or vitamin D, and there was a significant bone turnover reduction. The fortification of breakfast cereals and

dairy products had negligible health effects on a sample population aged 5 to 15 years.

## CONCLUSIONS

The data obtained from the study shows that the addition of vitamin D is present in fortified foods on the national market, most frequently in spreads, plant-based drinks, drinking yogurt, breakfast cereals and soy-based products. Fortified foods are not widely recognized by Romanian consumers, nonetheless, they are regarded as a valuable source of micronutrients. The range of fortified foods is diverse, helping in conjunction with regular foods and dietary supplements to meet the need for micronutrients. Insufficient evidence exists to support the notion that a regular diet and fortified foods can adequately meet the individual requirements for vitamin D.

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