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Sunflower oil with vitamin D: Preliminary investigation of enrichment possibility

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Abstract

Fat soluble vitamins, including vitamin D, are not sufficiently represented in the human diet. Although vitamin D can be synthesized in the body by direct exposure of the body to the sun, often people don't get enough sun exposure to assure enough vitamin D. Previous research has established that vitamin D deficiency is considered to be a highly prevalent nutritional problem worldwide. Vitamin D plays an important role in the optimal health including mediating calcium and phosphorus absorption, bone health metabolism, reducing cancer risk, prevention of cardiovascular diseases and insulin resistance. Optimal intake of vitamin D is an important issue for all races, ages and genders. Fatty fish and oil from the liver of various fish, as natural sources of vitamin D, are rarely present in the human diet worldwide, wherefore food fortification is a potential way to improve intake of vitamin D in the population. In order to select an appropriate food as a carrier for vitamin D fortification, several factors such as availability, cost, and stability during the cooking process should be considered. In addition, it should be noted that the amount of added vitamin D should be high enough to provide an adequate amount, and on the other hand, to prevent the risk of excessive intake of vitamin D. Vitamin D is, as previously mentioned, fat soluble, while vegetable oils and fats are present in the daily diet, so the aim of this work was to enrich sunflower oil with vitamin D3 (cholecalciferol). Cold-pressed oils are mainly used as salad oils, without additional heat treatment, which is why cold-pressed sunflower oil was used for fortification. On the other hand, high oleic acid content provides good oxidative characteristics, so high-oleic sunflower oil was chosen. Fortification achieved a vitamin D3 content of 210 μg/100 mL in this oil. A portion of 15 mL of sunflower oil contains 31,48 μg of vitamin D3, while a portion of 5 mL contains 10,5 μg of vitamin D3.

Keywords: cold-pressed oils, sunflower oil,food fortification, vitamin D.

1. INTRODUCTION

Vitamin D, as a fat-soluble vitamin and hormone precursor, plays a key role in optimal health, including mediating calcium and phosphorus absorption, bone health, reducing cancer risk, preventing cardiovascular disease and insulin resistance rajakumar2003, chiu2004. It is generally accepted that optimal vitamin D intake is an important issue for all races, ages, and genders (Lips et al. 2001). Therefore, in the past decade, several studies and scientific conferences dedicated to investigating the role of vitamin D in human health and disease prevention were organized allen2015. Natural sources of vitamin D are the sun's ultraviolet B radiation (UVB), as the main source, fatty fish and oils from the liver of various fish that are not so common in the daily diet of the population (O'Donnell et al. 2008). Furthermore, vitamin D can be taken from artificial sources such as supplements and foods fortified with this vitamin because common foods do not contain sufficient amounts of vitamin D (Grant & Holick 2005; Moulas & Vaiou 2018). Means deliberately increasing the content of essential micronutrients in a food so as to improve the nutritional quality of food and to provide public health benefit with minimal risk to health. Food fortification (Figure 1) in general is a potential way to im-

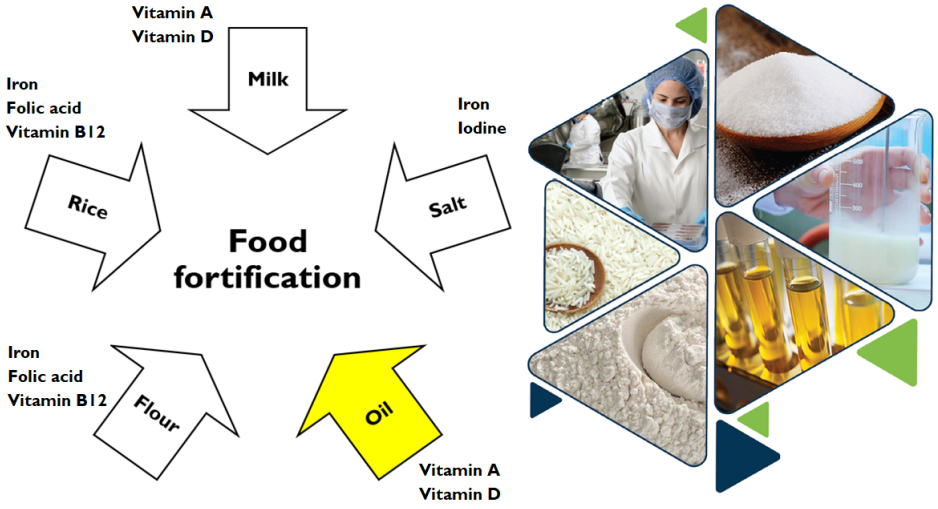

Figure 1. Food fortification: The solution (Food Fortification Resource Centre (FFRC) 2017).

prove its properties, and also to ensure and improve the intake of vitamin D in the human population (Cashman & Kiely 2014). In order to select an appropriate food as a carrier for vitamin D fortification, several factors such as availability, cost, and stability during use should be considered (Calvo, Whiting, & Barton 2004). In addition, it should be noted that the amount of added vitamin D should be high enough to ensure adequate intake, and on the other hand, to prevent the risk of excessive intake of this vitamin (Black, Seamans, Cashman, & Kiely 2012). About one billion people worldwide have problems due to vitamin D deficiencies. Recent studies have shown that even the population of some Mediterranean and tropical countries, including Turkey, India, Iran, Saudi Arabia and China, have been diagnosed with vitamin D deficiency, as many as 30 to 93 % (Heshmat et al. 2008), while, according to the report of Iran's National Food and Nutrition Surveillance Program, over 70% of Iran's population, aged between 12-65 years, has hypovitaminosis of vitamin D, even in summer (National Nutrition FTRI 2015). Therefore, for adequate vitamin D intake, fortified foods daily uded in diet can be an extremely good source, especially for those populations that have little exposure to sunlight or cannot afford the often expensive vitamin D supplements (Ruston, Hoare, Henderson, & Swan 2004). Several studies that included the population of the Republic of Serbia showed a low intake of vitamin D (Milešević, Nikolić, Gurinović, & Glibetić 2018). Vitamin D, as already mentioned, is fat-soluble, while vegetable oils and fats are present in the daily diet, so the aim of this paper was to enrich sunflower oil with vitamin D3 (cholecalciferol). Edible unrefined, cold-pressed oils are mainly used as "salad" oils, without additional (thermal) processing that can affect the added vitamin. For the aforementioned reason, cold-pressed sunflower oil was used for enrichment. On the other hand, the high content of oleic acid gives good oxidative characteristics, so high-oleic sunflower oil was chosen.

2. MATERIAL AND METHODS

2.1. Material

High-oleic cold-pressed sunflower oil produced by "Bački Dukat Plus" d.o.o., Odžaci, was used for the investigation in this paper. Vitamin D3 produced by "Divis Nutraceuticals", NJ, USA, concentration 1,000,000 - 1,100,000 IU/g was added to the oil. The vitamin D3 preparation is a clear, yellow liquid, containing cholecalciferol dissolved in MTC oil (an oil containing medium-chain triacylglycerols, such as triacylglycerols from coconut or palm kernel oil). An antioxidant, di-alpha-tocopherol, was added to the preparation. Vitamin D3 was dosed into the oil via a cylindrical tank with a 20 L mixer. Homogenization of the sample was done by constant mixing during and after vitamin D dosing.

2.2. Methods

Investigation of vitamin D3 content was determined by high performance liquid chromatography (HPLC) with a UV detector according to the standard method described in SRPS EN 12821:2012.

3. RESULTS AND DISCUSSION

Vitamin D3 was dosed according to the recommendations of the EFSA (*European Food Safety Authority*). Recommended dose differs depending on the consumers categories, as shown in Table 1.

Table 1. EFSA recommendations for vitamin D3 intake for different categories of consumers EFSA (2016).

Population	Age	Gender	Intake (μg/day)	Intake (IU)
Infants	7-11 month	Both	10	400 IU
Children	1-3 year	Both	15	600 IU
Children	4-6 year	Both	15	600 IU
Children	7-10 year	Both	15	600 IU
Children	11-14 year	Both	15	600 IU
Children	15-17 year	Both	15	600 IU
Adults	≥ 18 years	Both	15	600 IU
Pregnancy	≥ 18 years	Female	15	600 IU
Lactation	≥ 18 years	Female	15	600 IU

USDA (USDA2021) provided data of average vitamin D intake depending on daily caloric intake and the results obtained are presented in Table 2. The vitamin D content shown in Table 2, represents a weighted average of the vitamin D content of foods in each group, based on the relative consumption of each food item. It is used as a reference amount to calculate the total amount of nutrients expected from each group when different food choices are made within the group. The amount of vitamin D in the nutritional profile for the dairy group is based on about half of consumption coming from fortified liquid milk, yogurt, and soy milk, with the remaining half coming from cheese and other nonfortified dairy products, such as frozen dairy desserts. Dairy products contribute the majority of vitamin D in the pattern of the diet, about 65% in the pattern of 2000 kcal. The percentage of vitamin D from milk ranges from 57% in the 3200 kcal pattern to 76% in the 1000 kcal form. Protein foods, mainly seafood and eggs, contribute most of the rest, ranging from 16% to 29% of total vitamin D in patterns, with 25% in a 2000 kcal pattern. Cereals contribute smaller amounts, about 6 to 10% (from fortified RTE grains), and vegetables (mushrooms) contribute about 0.1 to 0.2% of vitamin D in these patterns. Solid fats (butter) also contribute very small amounts of vitamin D. Vegetable oils and fats are included in the 2000 kcal diet with 45 g per day, however, they are not a source of vitamin D.

The USDA recommendations are in line with the recommendations of the EFSA and limit the intake of vitamin D3 to 15 μg per day (600 IU), while the Regulations of declaration of the Republic of Serbia stipulate daily intake of vitamin D at 5 μg/day (200 IU) (*Pravilnik o deklarisanju, označavanju i reklamiranju hrane* 2017).

In accordance with the recommendations, vitamin D preparation in the amount of 0.0085% was dosed into the oil. In order to improve sample homogenization, the vitamin D was dissolved in a small amount of oil, afterwards oil mixture was dosed into the rest of the oil in a tank with a mixer. Table 3 shows obtained results for investigated oil in different serving portions compared to the available reference, i.e. adequate intakes according to different sources used.

Table 2. Vitamin D intake in current USDA Dietary Patterns, in IU (International Units)

Caloric intake (kcal)	Vitamin D (IU)
1000	157
1200	202
1400	218
1600	266
1800	268
2000	274
2200	283
2400	294
2600	298
2800	309
3000	310
3200	313

Table 3. Vitamin D3 (cholecalciferol) content in the analyzed sample of cold-pressed high-oleic sunflower oil and reference intake of vitamin D (D3) according to different sources.

Serving portion	Vitamin D (D3) content		
	mg	μg	IU
100 ml*	0,21	210	8400
5 ml**	0,011	10,5	420
15 ml***	0,032	31,5	1259
Reference intake			
EFSA, 2016	-	10-15§	400-600§
USDA, 2021	-	-	157-313§
Pravilnik, 2017	-	5§§	-

*) the oil amount according to information given in the nutritional declaration of the product
*) 1 serving portion (small coffee spoon)
***) 1 serving portion (large tablespoon)
§) daily intake
§§) nutritional reference value (NRV) of 2000 kcal pattern

In order to investigate the vitamin D3 (cholecalciferol) content in the analyzed sample (cold-pressed, high-oleic sunflower oil), a value of 0.21 mg/100 mL, i.e. 210 μg/100 mL of oil, containing 8400 IU, was obtained.

Since these oils are most often used directly, or as a salads oil, addition to cold dishes, etc., it makes sense to exoress the obtained values into adequate oil serving portions: 5 mL (a small coffee spoon) or 15 mL (a large tablespoon). The obtained results indicate that the serving portion of 5 mL contains 420 IU of vitamin D3, while the serving portion of 15 mL contains 1259 IU of vitamin D3 (Table 3).

4. CONCLUSIONS

Vegetable oils and fats are not a source of vitamin D in the diet of the human population, however, as a common component of the food pyramid, are consumed daily. In addition, vitamin D is soluble in oils and fats, which makes them suitable foods for vitamin D fortification. Since the vitamin D content is reduced by heat treatment, cold-pressed oils are particularly suitable for fortification, which are most often used for direct consumption and/or as salad oils. Sunflower oil is widespread in the diet of people in our region, so the enrichment of cold-pressed sunflower oil represents a potential possibility for ensuring a better intake of vitamin D in this way, in the daily diet of the population. Addition of vitamin D preparations in the amount of 0.0085% in oil ensure satisfaction of daily needs of the majority of the population for vitamin D3 (600 IU), in the amount of only 7 mL. There is no need to provide this vitamin from other sources.

5. ACKNOWLEDGMENTS

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6. CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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