

Appendix E-3.3: Meeting Vitamin D Recommended Intakes in USDA Food Patterns

RESEARCH QUESTION

Can vitamin D EARs and/or RDAs be met with careful food choices following recommended amounts from each food group in the USDA Food Patterns? How restricted would food choices be, and how much of the vitamin D would need to come from fortified food products?

BACKGROUND

Note: Please see DGAC Report Appendix E3.1, *Modeling Analysis: Adequacy of USDA Food Patterns* for more background information about development of the USDA food patterns.

The USDA Food Patterns are intended to represent the types and amounts of foods that will provide sufficient nutrients to meet IOM nutrient recommendations and Dietary Guidelines for Americans recommendations, within calorie needs. They are updated every five years during the deliberations of the Dietary Guidelines Advisory Committee, and are presented to the Committee for their assessment of how well the Patterns meet their goals. As part of the update, amounts recommended from each food group may be modified to reach all or most of the specified goals.

Food Patterns are created at 12 energy levels. Each level is assigned nutrient goals for one or more age-gender groups, for whom the energy level is appropriate, based on IOM Estimated Energy Requirement equations. See the food pattern modeling report on Adequacy of the USDA Food Patterns for detailed information on the development and evaluation of the overall USDA Food Patterns.

Vitamin D presents a unique case for the USDA Food Patterns, because it is not present in most of the foods commonly consumed by Americans. Most intake in the U.S. is from fortified foods and supplements. Sunlight exposure can contribute vitamin D via the conversion of pre-vitamin D in the skin to vitamin D from ultraviolet radiation. However, the IOM Estimated Average Intake (EAR) of 400 IU (10 µg) and Recommended Dietary Allowance (RDA) of 600 IU (15 µg) for most individuals assumes little or no sunlight exposure due to the relatively little skin exposure in certain geographical regions, especially in winter.

METHODS

1. Identify amounts of Vitamin D in USDA Food Patterns at each calorie level, and how much of this amount is contributed by each food group or food.
2. Using the 2000-calorie Pattern as an example, identify food choices that could provide the additional amounts needed of naturally occurring and/or fortified vitamin D to meet the EAR or RDA.

- a. Include a larger proportion of vitamin D-fortified Dairy products (fluid milk, yogurt, and soymilk) in the Patterns, replacing some non-fortified Dairy products (cheese, frozen dairy desserts).
 - b. Include vitamin D-fortified fruit juice for $\frac{3}{4}$ cup per day of the fruit in the Pattern
 - c. Include vitamin D from all grains that can be fortified under current regulations, at their maximum level of fortification.
 - d. Include only seafood with higher amounts of vitamin D in the Pattern
3. Assess the impact on flexibility in food choices if trying to meet the EAR or RDA through naturally occurring and fortified food sources alone.

RESULTS

Amounts in the USDA Food Patterns and food group sources in the Patterns

The amounts of vitamin D in the USDA Food Patterns at each calorie level are identified in Table 1. Amounts in the Patterns range from 157 IU in the 1000-calorie Pattern up to 313 IU in the 3200-calorie Pattern. At 2000 calories, amount is 274 IU. In no Pattern does the amount of vitamin D meet the RDA or the EAR.

Table 1. Amount of Vitamin D in current USDA Food Patterns, in IU

USDA Food Pattern (calorie level)	Vitamin D in Pattern (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

Source: DGAC Report Appendix E3.1, *Modeling Analysis: Adequacy of USDA Food Patterns*, Table E3.1.A7

Table 2 shows the amount of vitamin D in the nutrient profile for each food group or subgroup in the Patterns, and the amount of vitamin D from each group in the 2000-calorie Pattern. The nutrient profile amount is a weighted average of the vitamin D content of the foods in each group, based on relative consumption of each food. It is used as the reference amount for calculating the total amount of a nutrient expected from each group when a variety of food choices within the group are made. The amount of vitamin D in the nutrient profile for the Dairy

group is based on about half of consumption coming from fortified fluid milk, yogurt, and soymilk, and the remaining half from cheese and other non-fortified dairy products, such as frozen dairy desserts.

Dairy products contribute the majority of the Vitamin D in the Food Patterns, about 65% in the 2000-calorie Pattern. The percent of vitamin D from Dairy ranges from 57% in the 3200-calorie Pattern up to 76% in the 1000-calorie Pattern.

Protein foods, mostly seafood and eggs, contribute most of the rest, ranging from 16% to 29% of the total vitamin D in the Patterns, with 25% in the 2000-calorie Pattern. Grains contribute lower amounts, about 6 to 10% (from fortified RTE cereals), and vegetables (mushrooms) contribute about 0.1 to 0.2 % of the vitamin D in the Patterns. Solid fats (butter) also contribute very small amounts of vitamin D.

Table 2. Vitamin D in the nutrient profile for each food group/subgroup and amount in the 2000-calorie Pattern from each food group/subgroup

Food group	Nutrient Profile reference amount	vitamin D in nutrient profile (IU)	Amount in 2000-calorie Pattern	Vitamin D contributed to 2000-calorie Pattern (IU)
Fruit	1 cup eq	0	2 cup eq	0
Vegetables				
--Dark green	1 cup eq	0	.21 cup eq	0
--Red-orange	1 cup eq	0	.79 cup eq	0
--Beans & Peas	1 cup eq	0	.21 cup eq	0
--Starchy	1 cup eq	0	.71 cup eq	0
--Other	1 cup eq	0.5	.57 cup eq	.3
Grains				
--Whole grains	1 ounce eq	6	3 ounce eq	18
--Refined grains	1 ounce eq	1	3 ounce eq	3
Protein Foods				
--Meats	1 ounce eq	4	1.80 ounce eq	7
--Poultry	1 ounce eq	1	1.49 ounce eq	2
--Seafood—high omega-3	1 ounce eq	99	.26 ounce eq	25
--Seafood—low omega-3	1 ounce eq	20	.90 ounce eq	18
--Eggs	1 ounce eq	44	.41 ounce eq	18
--Soy Products	1 ounce eq	0	.06 ounce eq	0
--Nuts and Seeds	1 ounce eq	0	.59 ounce eq	0
Dairy	1 cup eq	59	3 cup eq	178
Oils	1 gram	0	27 g	0
Solid Fats	1 gram	.3	18 g	5
Added Sugars	1 gram	0	30 g	0

Source: DGAC Report Appendix E3.1, *Modeling Analysis: Adequacy of USDA Food Patterns*, Tables E3.1.A1, E3.1.A5.

Food sources and options for increasing amounts of vitamin D:

The amount of vitamin D per 100 grams of various foods was compiled from the Nutrient Database for Standard Reference, Release 26 (SR26). These amounts were converted to the amount per cup or ounce equivalent using the Food Pattern Equivalents Database (FPED) for NHANES 2009-10. Seafood sources of vitamin D (cooked forms only) and major fortified food sources of vitamin D are listed in Table 3.

Table 3. Food sources and amounts of vitamin D.

Food	Portion size	Vitamin D content*
Fortified dairy products		
--Milk	1 cup eq	115 IU
--Yogurt (fortified)	1 cup eq	115 IU
Other fortified foods		
--Orange juice	1 cup eq	100 IU
--RTE cereals (Cheerios)	1 oz eq (28 g)	38 IU
--RTE cereals (Total)	1 oz eq (30 g)	100 IU
Eggs		
	1 oz eq (1 egg)	44 IU
Seafood		
--Salmon, sockeye, canned	1 oz eq	238 - 243 IU
--Trout, rainbow, cooked	1 oz eq	224 IU
--Swordfish, cooked	1 oz eq	204 IU
--Salmon, pink, canned	1 oz eq	159 – 164 IU
--Salmon, sockeye, cooked	1 oz eq	149 IU
--Salmon, pink, cooked	1 oz eq	148 IU
--Sturgeon, cooked	1 oz eq	146 IU
--Mackerel, cooked	1 oz eq	131 IU
--Salmon, coho, cooked	1 oz eq	128 IU
--Salmon, chum, canned	1 oz eq	109 IU
--Mackerel, canned	1 oz eq	83 IU
--Tuna, light, canned in oil	1 oz eq	78 IU
--Salmon, Atlantic, farmed, cooked	1 oz eq	77 IU**
--Herring, cooked	1 oz eq	62 IU
--Sardines, canned in oil	1 oz eq	56 IU
--Tilapia, cooked	1 oz eq	42 IU
--Tuna, white, canned in water	1 oz eq	23 IU
--Tuna, light, canned in water	1 oz eq	13 IU

*Calculated from data per 100 g from NDL, SR26, converted to cup or ounce eqs using FPED for 2009-10.

**Data from Canadian government database, per Nutrient Data Laboratory staff.

Several options were explored to increase the amount of vitamin D in the Food Patterns to the EAR or RDA level. The 2000-calorie Pattern was used as an example.

1. The proportion of Dairy consumed from a fortified product was increased from about half to $\frac{3}{4}$ of total Dairy intake.
2. Fortified fruit juice was included for $\frac{3}{4}$ cup of fruit intake per day.
3. Grain products that are allowed under current regulations to be fortified with vitamin D were included at the maximum levels now allowed. See Table A1 (end of document) for products and calculations.
4. Options 1, 2, and 3 together.

The change in the Dairy nutrient profile would limit but not eliminate the amount of cheese and other non-fortified products (e.g., ice cream) that could be included in the Pattern. Based on current consumption proportions, cheese now accounts for about 1.5 cup eqs, or 2.25 ounces, per day in the 2000-calorie Pattern. This change would reduce it to .75 cup eqs, or about 1 ounce of cheese per day.

Fruit juice now accounts for about .6 cup eqs of the 2 cup eqs of total fruit in the 2000-calorie Pattern. Therefore, incorporation of $\frac{3}{4}$ cup of fortified juice would require only a minor change in whole fruit consumption.

The current patterns include only a few grain products that are fortified with vitamin D. These are ready-to-eat (RTE) cereals, for which the most common consumer choices are now fortified. For this analysis, the nutrient profiles of the whole and refined grain groups were altered to assume that all grain products allowed to be fortified under current FDA regulations would be fortified. These products include all enriched pasta, rice, and cornmeal; and all RTE and cooked cereals (Table A1, at end of document). However, it is important to note that very few of these products in the marketplace today are fortified with vitamin D.

The results of the options above on levels of vitamin D in the Pattern are presented in Table 4.

Table 4. Vitamin D in the 2000-calorie Food Pattern with increased vitamin D-fortified food in the Dairy, Fruit, and Grain groups.

Food Group or component	Current 2000 calorie Pattern	Pattern with Fortified Dairy at 75% total	Pattern with Fortified fruit juice at ¾ cup per day	Pattern with Fortified grain products	Pattern with All 3 Modifications
	Vit D (IU)	Vit D (IU)	Vit D (IU)	Vit D (IU)	Vit D (IU)
Fruit	0	0	75	0	75
Vegetables*	0.3	0.3	0.3	0.3	.3
Whole grains	18	18	18	63	63
Refined grains	3	3	3	63	63
Meat	7	7	7	7	7
Poultry	2	2	2	2	2
Seafood--high n3	25	25	25	25	25
Seafood--low n3	18	18	18	18	18
Eggs	17	17	17	17	17
Dairy	178	259	178	178	259
Solid fats	5	5	5	5	5
TOTAL	274	354	348	378	534

*mushrooms

With an increase in the proportion of Dairy foods that are fortified, the addition of fortified fruit juice, and the assumption that all allowed grains were fortified with vitamin D, the 2000-calorie Food Pattern would contain 534 IU of vitamin D, much closer to the RDA of 600 IU..

To meet the RDA, a change in seafood choices was examined. The amount of vitamin D per ounce of seafood that would be needed to meet the RDA was calculated, based on the current Patterns and the modified Patterns shown in Table 4.

The USDA Food Patterns include at least 8 ounces a week of seafood for all children over 9, adolescents, and adults. This translates to a daily average of 1.14 oz eq in the 2000-calorie Pattern. The nutrient profiles for seafood include both those high in omega-3 fatty acids and those lower in omega-3 fatty acids, in proportions now consumed. The amount of vitamin D per day and per oz eq of seafood that would bring the 2000-calorie Pattern to the RDA was calculated.

For the current 2000-calorie Pattern, the amount of vitamin D from seafood per day needed to meet the RDA is 369 IU (Table 5). For the modified Pattern it is 109 IU per day. Therefore, seafood would need to contain at least 323 IU of vitamin D per oz eq to meet the RDA in the 2000-calorie Pattern, if this were the only change made. No seafood listed in SR26 meets this requirement. For the modified Patterns, the seafood choices would need to contain at least 96 IU

per ounce equivalent. As shown in Table 3, a few seafood choices contain this amount of vitamin D. Several types of salmon, rainbow trout, swordfish, and mackerel contain at least this amount of vitamin D. Note that the most commonly consumed types of seafood are tuna, shrimp, salmon, cod, tilapia, “unknown”, flounder, crab, and catfish. Of these, only some but not all types of salmon would meet the level of vitamin D calculated to meet the RDA, when combined with the other modifications.

Table 5. Amounts of Vitamin D in 2000-calorie USDA Food Pattern needed to meet RDA

	Current USDA 2000 calorie Pattern	Modified USDA 2000 calorie Pattern
	Vitamin D (IU)	Vitamin D (IU)
Total in Pattern	274	534
Amount from Seafood	43	43
Deficit from RDA (600 IU) without seafood contribution	369	109
Amount of seafood per day in Pattern	1.14 oz eq	1.14 oz eq
Vitamin D needed per 1 ounce eq of seafood to make up deficit	323	96

SUMMARY

Amounts of vitamin D in the USDA Food Patterns do not currently meet wither the RDAs or the EARs for vitamin D. Several options were explored to increase levels of vitamin D to the RDA, without changing the overall amounts of food recommended from a food group or subgroup. Increased amounts of fortified Dairy products (Milk, yogurt) and use of fortified fruit juice would bring the amount of vitamin D in the 2000-calorie Pattern to the EAR level. Based on the assumption that additional Grain products could be fortified with vitamin D under current FDA regulations, the including these products at the maximum level of fortification raised the amount of vitamin D in the 2000-calorie Pattern closer to, but still not meeting, the RDA. Finally, encouraging seafood choices with the highest amounts of vitamin D, combined with the changes in Dairy and fruit juice choices, and potential fortification of additional Grain products, would bring the amounts of vitamin D in the 2,000-calorie USDA Food Pattern to the RDA level. However, this would limit seafood choices to a small number of types of seafood, which do not include most of those that are widely consumed.

Data sources

Nutrient data:

USDA National Nutrient Database for Standard Reference, Release 26. Available at <http://ndb.nal.usda.gov/>

Food intake data:

What We Eat in America (WWEIA), National Health and Nutrition Examination Survey 2009-10. Available at <http://seprl.ars.usda.gov/Services/docs.htm?docid=13793>

Food Group data:

Food patterns equivalents database (FPED) for WWEIA 2009-10: Available at <http://seprl.ars.usda.gov/Services/docs.htm?docid=23869>

Usual Intake distributions:

Usual Dietary Intakes: Food Intakes, US Population, 2007-10, National Cancer Institute. Available at <http://appliedresearch.cancer.gov/diet/usualintakes/pop/2007-10/>

Food availability data:

Food Availability Data System, USDA Economic Research Service. Available at [http://www.ers.usda.gov/data-products/food-availability-\(per-capita\)-data-system.aspx](http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system.aspx)

Table A1**Allowable vitamin D fortification (from FDA):**

Addition of vitamin D is optional in foods with Standards of Identity (SI), except for nonfat dry milk fortified with vitamins A and D (21 CFR 131.127) and evaporated milk (21 CFR 131.130).

Vitamin D is also affirmed GRAS under 21 CFR 184.1950 and has strict limitations with respect to the categories of food, functional use, and level of use.

Furthermore, vitamin D is also an approved food additive under 21 CFR 172.379 (vitamin D2), and 172.380 (vitamin D3).

Foods	CFR §		Levels
<i>Fluid Milk</i>	131.110 SI*	Optional unless milk is fortified	400 IU/quart (or 42 IU/ 100 g) within limits of good manufacturing practices (GMP)
<i>Acidified milk</i>	131.111 –SI	Optional	400 IU/quart
<i>Cultured milk</i>	131.112 – SI	Optional	400 IU/quart
<i>Concentrated milk</i>	131.115 – SI	Optional	400 IU/quart
<i>Nonfat dry milk, fortified with vitamin A and D</i>	131.127 – SI	Required	400 IU/quart
<i>Evaporated milk</i>	131.130 – SI	Required	25 IU/ounce
<i>Dry whole milk</i>	131.147 – SI	Optional	400 IU/quart (reconstituted product)
<i>Yogurt</i>	131.200 131.203	Optional	400 IU/quart
<i>Low-fat yogurt Nonfat yogurt</i>	131.206 SI		
<i>Milk products**</i>	GRAS 184.1950	Optional	89 IU/100 grams maximum level
<i>Enriched corn meal</i>	137.260 SI	Optional	Not < than 250 USP units/lb and not > than 1,000 USP units/lb

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<i>Enriched rice</i>	137.350 SI	Optional	Not < than 250 USP units/lb and not > than 1,000 USP units/lb
<i>Enriched macaroni products</i>	139.115 SI	Optional	Not < than 250 USP units/lb and not > than 1,000 USP units/lb
<i>Enriched noodle products</i>	139.155 SI	Optional	Not < than 250 USP units/lb and not > than 1,000 USP units/lb
<i>Grain products and Pasta[#]</i>	GRAS 184.1950	Optional	90 IU/ 100 g maximum level
<i>Enriched farina</i>	137.305 SI	Optional	Not < than 250 USP units/lb 350 IU/100g (maximum based on GRAS 184.1950)
<i>Breakfast cereal^{&}</i>	GRAS 184.1950	Optional	350 IU/100 g maximum level
<i>Margarine</i>	166.110 SI	Optional	Not < than 1500 IU/ lb
<i>Olestra</i>	172.867 (food additive)	Required	12 IU /g of Olestra [%]
<i>Calcium fortified juices and drinks[§]</i>	172.380 (food additive)	Optional	Not to exceed 100 IU / per 240 ml in 100 % fruit juices or fruit drinks [!]
<i>Cheese and cheese products[€]</i>	172.380 (food additive)	Optional	Not to exceed 81 IU / per 30 grams in cheese and cheese products
<i>Meal replacement bar</i>	172.380 (food additive)	Optional	Not to exceed 100 IU / per 40 grams in meal replacement bars or other type of bars that are represented for special dietary use in reducing or maintaining body weight
<i>Soy protein based meal replacement beverages</i>	172.380 (food additive)	Optional	Not to exceed 140 IU / per 240 ml (prepared beverage)

<i>Soy beverage</i>	172.379 (food additive)	Optional	50 IU/100 g maximum levels in food
<i>Soy beverage products</i>	172.379 (food additive)	Optional	89 IU/100 g maximum levels in food
<i>Soy butter substitute spreads</i>	172.379 (food additive)	Optional	330 IU/100 g maximum levels in food
<i>Soy based cheese substitutes and soy-based cheese substitute products</i>	172.379 (food additive)	Optional	270 IU/ 100 g maximum levels in food

*SI = standards of identity

@ See the FDA document (subject: recommended levels of vitamins A and D in milk products)

**Milk products (those that are not covered under standards of identity) including flavored milks and milk drinks, dry milks, toppings, snack dips, spreads, weight control milk beverages, and other milk origin products.

Grain products and pastas (those that are not covered under standards of identity) including macaroni and noodle products, rice dishes, and frozen multi-course meals, without meat or vegetables.

&Breakfast cereals (GRAS # 184.1950) including ready to eat and instant and regular hot cereals.

% To compensate for any interference with absorption of fat-soluble vitamin, vitamin D shall be added to foods containing olestra

§Excluding fruit juice and drinks formulated for infants (see below).

¹Fruit juices are fortified ≥ 33% or ≥ 10% of the RDI of calcium per 240 ml of 100 % fruit juice or fruit drinks, respectively.

€Cheeses, including curd, and whey cheeses, cream, natural, grating, processed, spread, dip and miscellaneous cheeses. Except cottage cheese, ricotta cheese and hard grating cheeses such as Parmesan and Romano.