Estimation of the Vitamin D Content of Foods for the Assessment of Dietary Intake

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ABSTRACT

Vitamin D is important for bone health, and growing evidence indicates that it may reduce the risk of other diseases including colon cancer. This has resulted in great interest in being able to assess the dietary intake of vitamin D in the U.S., since many factors can impair sunlight-induced cutaneous vitamin D synthesis. To estimate vitamin D intake in large scale surveys, nutrient values must be in the USDA National Nutrient Database for Standard Reference (SR). Of the 7,000 foods in SR, about 2,800 foods form the foundation of the Food and Nutrient Database for Dietary Studies (FNDDS), used in the What We Eat in America dietary component of NHANES.

In order to provide current and accurate vitamin D values for these 2,800 foods, beginning in 2006, the Nutrient Data Laboratory (NDL) staff conducted a review and evaluation of literature data. At the same time, NDL began collaborating with other experts to assess and improve the analytical methods, to develop quality control materials, to identify and sample major food sources of vitamin D, and to analyze these foods. Vitamin D-fortified foods that were analyzed included: fluid milks, breakfast cereals, orange juice, yogurt, and processed cheese. Naturally occurring vitamin D was analyzed in high consumption fish, eggs, meat, and poultry. Once the core vitamin D data were obtained, NDL developed and implemented standard rules for imputing vitamin D values for any survey foods where analytical data were not available. Outside experts reviewed the final vitamin D values.

The updated and expanded vitamin D values will be released in SR22 in 2009 for all foods used in the FNDDS. The USDA/ARS Food Surveys Research Group will use these values in the creation of the FNDDS 4.0, thus permitting the estimation of vitamin D intake from foods for What We Eat in America 2007-2008.

INTRODUCTION

The scientific community is interested in knowing the dietary intake of vitamin D because of its importance for bone health and recent evidence that it may reduce the risk of other diseases. NDL undertook a collaboration with other experts to improve the analytical methodology for Vitamin D_3 (cholecalciferol) and to sample and analyze the major food sources of vitamin D. Using these analytical data as a base, NDL then used standard imputing procedures (providing nutrient values when analytical data are not available) to determine vitamin D values for all foods in SR22 that are used for the FNDDS.

Analytical Methodology Development

- Methods applicable to a variety of food matrices.
- Participating labs ran quality control analyses on an on-going basis. Results had to fall within an acceptable range of values.
- Control materials were: vitamin D fortified fluid milk, a fortified multigrain ready-to-eat cereal, orange juice fortified with calcium and vitamin D, pasteurized process cheese fortified with vitamin D, and canned red salmon (Phillips et al. 2008).
- All methods involved extraction with solvent(s), cleanup steps, and quantification by HPLC or by HPLC and LC/MS.

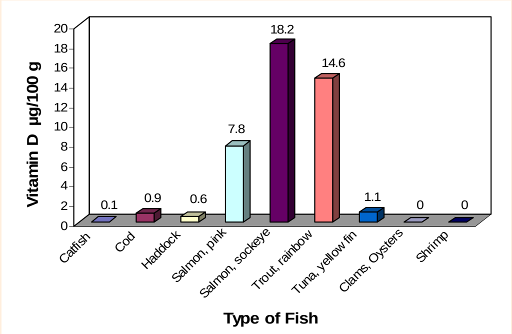
Food Sampling and Analysis

- A selection of foods representing natural vitamin D sources and fortified sources was chosen for sampling and analysis under the National Food and Nutrient Analysis Program (NFNAP) which involves nationwide multi-stage probability sampling (Haytowitz et al. 2008).
- Analyses have been completed for raw eggs and the following fortified products: fluid milk of 4 fat levels, lowfat chocolate milk, fruit yogurt, and orange juice. Vitamin D analyses have been completed for selected cuts/pieces of chicken, pork, and beef, under separate analytical programs (Table 1).
- Analytical values for fish are based on preliminary analyses under NFNAP (Figure 1); additional samples are being analyzed and values will be updated in future SR releases (Byrdwell 2009).

Table 1. Vitamin D results from NDL analytical programs

Food	Vitamin D, µg/100 g	Number of Datapoints	Standard Error
Milk, fluid, fortified:			
Whole, 3.25%	1.3	24	.082
Nonfat	1.2	24	.061
Chocolate, lowfat	1.1	24	.079
Yogurt, fruit, fortified	1.3	45	.016
Eggs, whole, raw	1.2	8	.300
Beef, chuck, raw, separable lean	0.1	10	.010
Beef, chuck, raw, separable fat	0.3	1	NA
Chicken, fried, meat only, dark and light	0.1	8	.043
Chicken, fried, skin	0.2	2	NA
Pork, blade chop, raw	0.6	1	NA
Pork, blade chop or roast, cooked	0.6 - 0.9	1	NA
Pork, ground, cooked	0.5	1	NA
Orange juice, chilled, fortified	1.4	39	.040

Figure 1. Results of NFNAP analyses of raw finfish and shellfish, n=1



Imputation Methods

- Assumed zero – values for foods not expected to contain quantifiable amounts of vitamin D were set to zero. This applies to foods of plant origin such as fruits, vegetables (except mushrooms) and grains.
- Other food composition databases
- Calculated from industry-declared % DV fortification levels (standard of identity or label claim)
- Calculated from similar food
- Determined by formulation or recipe techniques
  - ❖ Dairy industry provided guidance that most dairy products used as ingredients in formulated (commercial multi-ingredient) foods are not likely to be fortified with vitamin D.
  - ❖ Margarine/spread used in commercial products is generally not vitamin D fortified.
  - ❖ For ingredients that could be fortified at the retail level, but generally are not fortified at the food processing level, two related profiles are available in SR – one with added vitamin D and one without. When estimates were calculated for commercial formulated foods, the unfortified profile was used.
  - ❖ For home-prepared foods the fortified ingredient was selected for use in the recipe calculation.

Imputation Calculation Examples

Recipe: Coffee cake, dry mix, prepared
10.5 oz. cake mix + 1 whole egg + 0.5 cup reduced fat milk, applying appropriate retention factors, resulted in 0.5 µg vitamin D per 100 g cake

Label Claim: TOTAL™ ready-to-eat cereal
0.75 cup (30 g) serving = 25%DV (label claim) = 333.3 IU/100 g divided by 40 (IU to µg factor) = 8.3 µg/100 g cereal

Meat, Lean and Fat (recipe): Beef, chuck roast, separable lean and fat, cooked
(95.5% lean * 0.1 µg) + (4.5% fat * 0.4 µg) = 0.1 µg vitamin D/100 g lean and fat

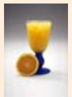
Calculated From Similar Food, Based on Fat: Cheddar cheese
0.06 µg/100 g whole milk without vitamin D * (33.14 g fat in cheddar cheese/3.27 g fat in whole milk) = 0.6 µg vitamin D/100 g cheddar cheese

Table 2. Vitamin D from other sources

Food	Vitamin D, µg/100g	Source of data
Fortified products:		
Breakfast cereals	1.7 - 8.3	Manufacturer or label claim
Egg substitutes	1.6	Label claim
Malted drink powder	23.5	Label claim
Milk, canned, evaporated	2	Product standard (CFR)
Processed American cheese	5.3	Label claim
Soymilk	1.0 - 1.2	Manufacturer
Anchovy, canned in oil	1.7	Table (Canadian Nutrient File)
Apples, raw	0	Assumed zero
Butter cookies, commercially prepared	0.4	Formulation
Lamb, all cuts	0.1	Scientific literature
Liver, beef	1.2	Scientific literature
Mushrooms, white, raw	0.5	Scientific literature
Pudding, prepared from mix	1.1	Recipe
Pudding, ready-to-eat	0	Formulation
Veal, raw and cooked	0	Scientific literature

DISCUSSION & CONCLUSIONS

Vitamin D values will be released in SR22 in the summer of 2009. Vitamin D (defined as the sum of D_2 and D_3) values, either analytical or imputed, are included for all 2,800 food items in SR that are used for the FNDDS. Mushrooms and fortified soy milk are the only products in the database that contain vitamin D_2 (ergocalciferol). The FNDDS will be used to estimate the vitamin D intake from foods for What We Eat in America.



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