Phylloquinone (Vitamin K_1) Content of Foods in the U.S. Food and Drug Administration's Total Diet Study

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Two hundred sixty-one foods from the U.S. Food and Drug Administration's Total Diet Study were analyzed for phylloquinone (vitamin K_1) using a high-performance liquid chromatographic method that incorporates postcolumn reduction of the quinone, followed by fluorescence detection of the hydroquinone form of the vitamin. Green, leafy vegetables still appear to be the predominant dietary source of this vitamin (113–440 μg of phylloquinone/100 g of vegetable), followed by certain vegetable oils that are derived from vegetables or seeds containing large concentrations of phylloquinone. Some mixed dishes contain moderate amounts of phylloquinone that are attributable to the vegetable oils used in their preparation. Other foods, such as certain meats, brewed beverages, soft drinks, and alcoholic beverages, contained negligible amounts of phylloquinone. These data expand and improve the quality and quantity of the phylloquinone food composition table and will be used to prioritize future analyses.

Keywords: *Phylloquinone; vitamin K_1; food composition; total diet study*

INTRODUCTION

Six vitamin K-dependent proteins have well-defined roles in the regulation of blood coagulation (Suttie, 1988). However, the requirement for vitamin K is not limited to its role in the regulation of blood clotting. Recent research has led to the hypothesis that vitamin K nutrition may play a role in the etiology of several metabolic diseases related to bone and cartilage metabolism (Knapen et al., 1989; Szulc et al., 1993). In light of the present state of knowledge regarding vitamin K's role in human nutrition, it is important to determine how much phylloquinone (vitamin K_1) is in the typical American diet in relation to the current daily Recommended Dietary Allowance of 0.5–1.0 μg/kg of body weight (NRC, 1989). To date, no accurate description of the phylloquinone content of foods commonly consumed in the United States is available.

A revised provisional table for phylloquinone content in some foods was recently compiled by using high-performance liquid chromatography (HPLC) data exclusively (Booth et al., 1993). Many of the values were generated from single analyses, with inadequate descriptions of sampling design and food preparation. Cooked and processed foods were poorly represented. In addition, food composition data for phylloquinone were collected from diverse sources throughout the world. Earlier work by Ferland and Sadowski (1992a) suggested that geographical variation in the phylloquinone content of certain food items limits how representative the data are in the provisional table for estimating the phylloquinone content of foods in the American diet.

We recently described HPLC preparation procedures for the determination of phylloquinone in various food matrices that were selected to represent foods commonly consumed in the United States (Booth et al., 1994). In this paper, we present values of phylloquinone content in foods obtained from the Food and Drug Administration's (FDA) Total Diet Study (TDS) analyzed according to these procedures. In the FDA-TDS, more than 250 core foods in the American food supply, representing foods consumed in the United States, are purchased from retail markets four times per year from different geographic regions (Pennington, 1992a). Analyses of these foods for phylloquinone have identified food classes that are potential contributors to phylloquinone intake in the United States and provide food composition data for the estimation of dietary intake of this vitamin by 14 age–gender groups.

METHODS

Collection and Preparation of Foods. The most recent FDA-TDS food list identified core foods in the American diet on the basis of data from the U.S. Department of Agriculture's (USDA) 1987–1988 Nationwide Food Consumption Survey (NFCS) (Pennington, 1992a). Individual foods and ingredients were collected from four sites per year in the United States and sent to the FDA Field Office Laboratory in Kansas City for preparation and processing according to instructions described by Pennington (1992b). Two hundred sixty-one foods were selected from the August 1993 TDS collection for phylloquinone determination. Each food was homogenized, and a 10-g portion was packed in domestic quality ziplock-type plastic bags. The 10-g portions were frozen, packed with frozen ice packs, and shipped by air to the Vitamin K Laboratory at the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University, where they were stored, protected from light, at −20 °C until analysis.

Phylloquinone Determination. Each homogenate was analyzed in triplicate for phylloquinone by an HPLC method that incorporates postcolumn reduction of the quinone followed by fluorescence detection of the hydroquinone form of the vitamin as described elsewhere (Booth et al., 1994). Briefly, 0.25–0.50 g from each homogenate was weighed directly into 50-mL polypropylene centrifuge tubes (Corning Co., Corning, NY). Vegetable, fruit, and meat homogenates were further processed to a fine powder by grinding with 10 times their weight in anhydrous sodium sulfate, followed by quantitative

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ransfer to a 50-mL centrifuge tube. An appropriate amount ıf the internal standard vitamin $K_{(1,25)}$ was added directly to he samples. Fifteen milliliters of 2-propanol/hexane (3:2 v/v) ınd 4 mL of H_2O were added, followed by sonification using a 3ranson Model 350 sonifer-cell disruptor with a $^1/_8$-in. tapered nicrotip (Branson Ultrasonics Corp., Danbury, CT). Thirty-wo milliliters of H_2O was added to those homogenates that vere further processed using anhydrous sodium sulfate. Samples were then vortexed (10 min) and centrifuged at 1000g 10 min). After phase separation, the upper hexane layer was ıspirated into a 16 × 100 culture tube and evaporated to lryness under reduced pressure in a centrifugal evaporator Savant Instrument Inc., Farmingdale, NY), and the residue vas redissolved in hexane (4–10 mL). An aliquot of the ·econstituted lipid extract was applied to a 3- or 6-mL solid-›hase extraction (SPE) silica column (J. T. Baker Inc., Chicago, L) which had been preconditioned by successive washes of 8 nL of hexane/diethyl ether (93:3 v/v) followed by 8.0 mL of ıexane. The size of the column used was determined by the ipid content of the food. The SPE silica column was washed vith an additional 8 mL of hexane after application of the ıample to remove the hydrocarbons. The phylloquinone-:ontaining fraction was eluted with 8 mL of hexane/diethyl ·ther (97:3 v/v). The eluate was collected and evaporated to lryness. To further purify the foods with a high lipid content, ıuch as the meats, butter, and margarine, a reversed-phase C_{18} SPE extraction was used. After evaporation, the residue rom the eluate was dissolved in 200 μL of 2-propanol by ıeating (45 °C) for 10 min. The reversed-phase C_{18} columns 6 mL) (J. T. Baker) were preconditioned by successive washes vith 6 mL of methanol/methylene chloride (80:20 v/v) followed ›y 6 mL of 100% methanol and 6 mL of 100% H_2O. The ıample was applied directly to the preconditioned packing. The :olumn was washed with 6 mL of 100% methanol/H_2O (95:5 ·/v), followed by 6 mL of 100% acetonitrile, and the sample ·luted from the column with 10 mL of methanol/methylene :hloride (80:20 v/v). The C_{18} SPE column eluate was collected ınd evaporated to dryness. The final residue for each sample vas reconstituted initially in 30 μL of 100% methylene :hloride, followed by 270 μL of methanol containing 10 mM :inc chloride, 5 mM acetic acid, and 5 mM sodium acetate. A 150-μL sample was injected into the HPLC. Quantitation of ›hylloquinone in the homogenates was achieved by direct :omparison of peak area ratios of the foods to authentic ıtandards of phylloquinone and vitamin $K_{(1,25)}$ using a Waters 360 chromatography data system (Waters Chromatography, Milford, MA).

All foods were analyzed within 7 months of collection and ›reparation. The procedures involving preparation and analy-ıis were performed under yellow lighting because vitamin K :ompounds are sensitive to photooxidation. The solvents used or extraction and chromatography were of HPLC grade Fisher Scientific Inc., Springfield, NJ). The internal standard ritamin $K_{(1,25)}$ that was used for all of the FDA-TDS analyses vas a gift from Hoffmann-La Roche and Co. (Basel, Switzer-and).

Recoveries of the internal standard in the homogenates, vhich ranged from 55 to 90%, corresponded to those previously ·eported by our laboratory (Booth et al., 1994; Ferland and Sadowski, 1992a,b). The analytical variation of the assay, lefined by the intra- and interday coefficients of variation ımong successive determinations of single food samples, ·anged from 6 to 14% (Booth et al., 1994). The lower limit of letection was set at 0.01 μg of K_1/100 g of food.

RESULTS AND DISCUSSION

The phylloquinone contents of foods from the August 1993 collection of the FDA-TDS are presented in Table 1. The vegetable group contained the highest overall :ontent of phylloquinone in the American diet, with a ·ange of 0.03–440 μg K_1/100 g of food. The vegetables :hat contained the greatest amounts of phylloquinone vere the dark, leafy greens such as boiled collards and ıpinach. In contrast, the root vegetables, such as white potatoes, radishes, and onions, contained trace amounts of phylloquinone.

The phylloquinone contents of vegetables that were homogenized in the raw form prior to freezing, such as iceberg lettuce and green peppers, were lower than corresponding values reported in the provisional table [122 μg of K_1/100 g of lettuce and 17 μg of K_1/100 g of pepper, respectively (Booth et al., 1993)]. The discrepancies between the two sets of phylloquinone values may reflect geographical variation as reported by Ferland and Sadowski (1992a). Alternatively, the lower values reported for the FDA-TDS foods could be indicative of phylloquinone losses associated with enzymatic destruction during preparation and storage. The effects of preparation and storage on the stability of phylloquinone in foods have not yet been investigated and should be an area for future research.

The fats and dressings group contained the second highest overall level of phylloquinone content in the FDA-TDS foods, with a range of 0.3–51 μg of K_1/100 g of food. Margarine, mayonnaise, and regular-calorie salad dressing, which are derived from vegetable oils, contained more phylloquinone than did animal fat sources, such as butter. These findings are consistent with previous data showing that animal products do not appear to contain appreciable amounts of phylloquinone (Parrish, 1980). However, when certain vegetable oils are used in packing or processing animal products, these foods become potentially important dietary sources of phylloquinone. Eggs, which contain trace amounts of phylloquinone in their raw form, contained 6.9 and 12 μg of K_1/100 g of egg when fried and scrambled, respectively. Tuna contains trace amounts of phylloquinone when packed in brine (M. J. Shearer, St. Thomas' Hospital, London, personal communication, 1993). The tuna analyzed in this study was packed in oil and contained 24 μg of K_1/100 g of tuna. It should be noted that the increase in phylloquinone content associated with the addition of oil is dependent on the type of oil used. Ferland and Sadowski (1992b) reported that soybean, canola, and olive oils were rich sources of phylloquinone, whereas peanut and corn oils are not. In the FDA-TDS, the only pure vegetable oils collected were olive and safflower oils. The vegetable oils used in the preparation of mixed dishes and in the commercial preparation of fats and dressings, such as mayonnaise and salad dressing, were representative of current market availability. Monitoring the food supply on a regular basis would identify changes in the types of oils used commercially because of their impact on the phylloquinone content of foods. Monitoring would also be important for commercially baked goods such as blueberry muffins, which, unlike the other grain products, contain large amounts of phylloquinone associated with the oils used in their preparation.

Snack foods and desserts were in the medium range for overall phylloquinone content, with ranges of 2.9–20 and 0.0–14 μg of K_1/100 g of food, respectively. The provisional table contains values for pretzels and potato chips (1 and 10 μg of K_1/100 g of food, respectively) that are comparable to those presented here. When the phylloquinone content of these foods is expressed per average serving size (Table 1), some of the dessert items, such as pies, are consumed in large enough quantities to be of potential importance to the dietary intake of this vitamin. Likewise, analysis of cooked and processed foods in their ready-to-eat form revealed that certain mixed dishes are moderate-to-rich sources of

Table 1. Phylloquinone (Vitamin K_1) Content of Core Foods in the U.S. FDA Total Diet Study

code	food name	phylloquinone content, mean (SD) (μg/100 g)	av serving size (g)	phylloquinone per serving (μg)	code	food name	phylloquinone content, mean (SD) (μg/100 g)	av serving size (g)	phylloquinone per serving (μg)
				A. Milk and Cheese					
A02	whole milk, fluid	0.3 (0.02)	244	0.7	A16	fruit-flavored yogurt, low fat (fruit mixed in)	3.0 (0.5)	227	6.8
A04	low-fat (2% fat) milk, fluid	0.2 (0.02)	244	0.5	A18	Cheddar cheese	2.1 (0.2)	28	0.6
A06	skim milk, fluid	0.01 (<0.01)	245	0.02	A20	Swiss cheese	2.8 (0.6)	28	0.8
A10	chocolate milk, fluid	0.2 (0.01)	250	0.02	A22	American, processed cheese	1.6 (0.05)	28	0.5
A12	evaporated milk, canned	1.6 (0.03)	32	0.5	A24	cottage cheese, 4% milk fat	0.4 (0.2)	113	0.5
A14	plain yogurt, low fat	0.1 (0.01)	227	0.2	A26	cream cheese	2.9 (0.6)	28	0.8
				B. Eggs					
B02	eggs, boiled	0.3 (0.05)	50	0.2	B04	eggs, fried	6.9 (0.2)	46	3.2
B06	eggs, scrambled	12 (0.05)	64	7.5					
				C. Meat, Poultry, and Fish					
C02	beef steak, loin, pan-cooked	1.8 (0.2)	85	1.5	C25	ham luncheon meat, sliced	<0.01 (<0.01)	56	<0.01
C04	beef chuck roast, baked	0.7 (0.2)	85	0.6	C26	salami, sliced	1.3 (0.08)	56	0.7
C06	ground beef, pan-cooked	2.4 (0.1)	85	2.0	C28	liver, beef, fried	2.7 (0.1)	85	2.3
C08	pork chop, pan-cooked	3.1 (0.07)	85	2.6	C30	chicken breast, roasted	<0.01 (<0.01)	85	<0.01
C10	ham, baked	<0.01 (<0.01)	85	<0.01	C32	chicken, fried (breast, leg, and thigh), homemade	4.5 (0.3)	85	3.8
C12	pork roast, baked	<0.01 (<0.01)	85	<0.01	C33	chicken nuggets, fast food	1.5 (0.2)	109	1.6
C14	lamb chop, pan-cooked	4.6 (0.5)	85	3.9	C34	chicken, fried (breast, leg, and thigh), fast food	1.3 (0.1)	85	1.1
C16	veal cutlet, pan-cooked	6.6 (0.4)	85	5.6	C36	turkey breast, roasted	<0.01 (<0.01)	85	<0.01
C18	pork bacon, pan-cooked	0.1 (0.05)	19	0.02	C38	fish sticks, frozen, heated	6.8 (0.2)	85	5.8
C20	pork sausage, pan-cooked	3.4 (1.4)	56	1.9	C40	haddock, pan-cooked	5.2 (0.1)	85	4.4
C22	frankfurters, beef, boiled	1.8 (0.5)	57	1.0	C44	tuna, canned in oil, drained	24 (1.2)	56	14
C24	bologna, sliced	0.3 (0.2)	56	0.2	C46	shrimp, boiled	<0.01 (<0.01)	85	<0.01
				D. Legumes and Nuts					
D02	pork and beans, canned	1.1 (0.02)	126	1.4	D10	peanut, dry, roasted	0.3 (0.2)	28	0.08
D04	kidney beans, dry, boiled	8.4 (0.9)	88	7.4	D12	peanut butter, smooth	0.3 (0.02)	32	0.1
D06	pinto beans, dry, boiled	3.7 (0.2)	86	3.2	D14	mixed nuts, no peanuts, dry roasted	13 (0.3)	28	3.6
D08	peas, mature, dry, boiled	5 (0.2)	98	4.9					
				E. Grain Products					
E02	white bread	1.9 (0.1)	50	1.0	E32	pancakes from mix	6.5 (0.6)	114	7.4
E04	whole wheat bread	3.4 (0.05)	57	1.9	E34	macaroni, boiled	0.05 (0.04)	140	0.07
E06	cracked wheat bread	3.5 (0.2)	50	1.8	E36	egg noodles, boiled	0.09 (<0.01)	160	0.1
E08	rye bread	3.0 (0.3)	62	1.9	E48	corn grits, regular, cooked	<0.01 (<0.01)	242	<0.01
E10	white roll	2.1 (0.3)	57	1.2	E40	oatmeal, quick (1–3 min), cooked	0.4 (0.04)	234	0.9
E12	bagel, plain	0.4 (0.01)	71	0.3	E42	white rice, cooked	<0.01 (<0.01)	102	<0.01
E14	English muffin, plain, toasted	0.3 (0.09)	57	0.2	E44	wheat cereal, farina, quick (1–3 min), cooked	0.06 (0.02)	233	0.1
E16	biscuit, from refrigerated dough, baked	4.6 (0.2)	70	3.2	E46	raisin bran cereal	1.6 (0.6)	56	0.9
E18	corn bread, homemade	7.4 (0.4)	65	4.8	E48	fruit-flavored, sweetened cereal	0.2 (<0.01)	35	0.07
E20	tortilla, flour	3.1 (0.1)	70	2.2	E50	cornflakes	0.03 (0.01)	25	0.01
E22	blueberry muffin, commercial	25 (0.7)	57	14	E52	oat ring cereal	0.8 (0.04)	25	0.2
E26	graham crackers	8.9 (0.2)	28	2.5	E54	shredded wheat cereal	1.5 (0.09)	47	0.7
E28	saltine crackers	3.6 (0.1)	30	1.1	E56	crisped rice cereal	<0.01 (<0.01)	28	<0.01
E20	butter-type crackers	13.1 (0.1)	30	3.9	E58	granola cereal	1.8 (0.1)	56	1.0
				F. Fruits					
F02	grapefruit, raw	<0.01 (<0.01)	154	<0.01	F30	pear, raw	4.9 (0.5)	166	8.1
F04	orange, raw	<0.01 (<0.01)	154	<0.01	F32	pear, canned in light syrup	0.2 (0.01)	158	0.3
F06	prunes, dried	1.4 (0.1)	42	0.6	F34	pineapple, canned in juice	0.3 (0.08)	116	0.3
F08	raisins, dried	1.7 (0.1)	36	0.6	F36	plums, raw	8.2 (3.7)	132	11
F10	applesauce, bottled	0.6 (<0.01)	128	0.8	F38	watermelon, raw	0.2 (0.03)	280	0.6
F12	apple, red, raw	1.8 (0.09)	154	2.8	F40	strawberries, raw	1.5 (0.3)	147	2.2
F14	apricot, raw	3.3 (0.4)	141	4.7	F42	fruit cocktail, canned in heavy syrup	2.6 (0.1)	128	3.3
F16	avocado, raw	14 (0.7)	30	4.3	F44	grapefruit juice, from frozen concentrate	0.05 (0.01)	247	0.1
F18	banana, raw	0.2 (0.02)	126	0.3	F46	orange juice, from frozen concentrate	<0.01 (<0.01)	249	<0.01
F20	cantaloupe, raw	0.4 (0.03)	134	0.5	F48	pineapple juice, from frozen concentrate	0.3 (0.04)	250	0.8
F22	sweet cherries, raw	1.5 (0.2)	140	2.1	F50	apple juice, bottled	<0.01 (<0.01)	244	<0.01
F24	grapes, red/green, seedless, raw	8.3 (0.7)	138	12	F52	grape juice, from frozen concentrate	0.4 (0.04)	250	1.0
F26	peach, raw	2.1 (0.4)	112	2.4	F54	prune juice, bottled	3.4 (0.2)	256	8.7

Table 1 (Continued)

				G. Vegetables					
G02	white potato, baked with skin	1.1 (0.1)	140	1.5	G42	cabbage, fresh, boiled	98 (10)	75	73
G04	white potato, boiled without skin	0.3 (0.02)	136	0.4	G44	coleslaw with dressing, homemade	100 (3.4)	120	119
G06	scalloped potatoes, homemade	3.3 (0.1)	122	4.0	G46	sauerkraut, canned	13 (6.5)	118	15
G08	French fries, fast food	4.4 (0.2)	68	3.0	G48	asparagus, fresh/frozen, boiled	80 (2.9)	90	72
G10	French fries, frozen, heated	7.1 (0.8)	70	5.0	G50	cauliflower, fresh/frozen, boiled	20 (4.6)	62	12
G12	mashed potatoes, from flakes	5.1 (0.2)	105	5.4	G52	celery, raw	32 (4.0)	55	17
G14	spinach, fresh/frozen, boiled	360 (70)	90	324	G54	corn, fresh/frozen, boiled	0.3 (0.2)	83	0.3
G16	collards, fresh/frozen, boiled	440 (85)	85	374	G55	cream style corn, canned	0.03 (0.01)	128	0.04
G18	broccoli, fresh/frozen, boiled	113 (2.5)	78	88	G56	cucumber, raw	2.2 (0.2)	99	2.2
G20	carrot, fresh, boiled	15 (0.5)	78	12	G58	iceberg lettuce, raw	31 (8.6)	89	28
G22	winter squash, fresh/frozen, baked, mashed	1.1 (0.2)	102	1.1	G60	mushrooms, raw	0.06 (0.01)	70	0.04
G24	sweetpotato, fresh, baked	2.4 (0.2)	114	2.7	G62	onion, mature, raw	0.3 (0.1)	148	0.4
G26	tomato, red, raw	3 (0.3)	148	4.4	G66	green peas, fresh/frozen, boiled	24 (0.8)	80	19
G28	tomato, stewed, canned	2.4 (0.3)	101	2.4	G68	green pepper, raw	2.5 (0.2)	148	3.7
G30	tomato juice, bottled	2.3 (0.1)	244	5.6	G70	summer squash, fresh/frozen, boiled	4.4 (0.6)	90	4.0
G32	tomato sauce, plain, bottled	2.9 (0.4)	61	1.8	G72	radish, raw	0.4 (0.06)	85	0.3
G34	green beans, fresh/frozen, boiled	16 (6.6)	62	9.7	G73	eggplant, fresh, boiled	2.9 (0.6)	96	2.8
G36	lima beans, immature, frozen, boiled	5.1 (0.7)	85	4.3	G74	turnip, fresh/frozen, boiled	0.07 (0.02)	78	0.06
G38	beets, fresh/frozen, boiled	1.2 (0.1)	85	1.0	G75	okra, fresh/frozen, boiled	40 (0.2)	80	32
G40	Brussels sprouts, fresh/frozen, boiled	289 (55)	78	225	G78	mixed vegetables, frozen, boiled	19 (3)	82	15
				H. Mixed Dishes and Meals					
H01	beef stew with potatoes, carrots, and onion, homemade	4.8 (0.1)	245	12	H25	quarter-pound cheeseburger on bun, fast food	4.1 (0.6)	219	9.0
					H26	quarter-pound hamberger on bun, fast food	3.8 (0.3)	218	8.3
H02	beef stroganoff, homemade	1.7 (0.05)	198	3.4	H27	fish sandwich on bun, fast food	17 (1.6)	158	26
H04	green peppers stuffed with beefe and rice, homemade	7.4 (1.3)	198	15	H28	frankfurter on bun, fast food	4.4 (0.5)	98	4.3
					H29	egg, cheese, and ham on English muffin, fast food	3.7 (0.6)	16	5.4
H06	meatloaf, homemade	12 (2.5)	85	10	H30	taco/tostada, from Mexican carryout	16 (1.5)	171	28
H08	chili con carne with beans, homemade	4.7 (0.9)	255	12	H32	cheese pizza, regular crust, from pizza carryout	4.2 (0.6)	130	5.5
H10	chicken potpie, frozen, heated	2.7 (0.3)	277	7.5	H33	cheese and pepperoni pizza, regular crust, from carryout	3.8 (0.4)	130	4.9
H12	tuna noodle casserole, homemade	20 (2.2)	240	48					
H14	lasagna with meat, homemade	5.3 (1.2)	198	11	H34	beef chow mein, from Chinese carryout	31 (3.7)	250	78
H16	spaghetti with tomato sauce andmeatballs, homemade	5.7 (0.6)	248	14	H36	bean with bacon/pork soup, canned, condensed	0.9 (0.2)	253	2.3
					H38	chicken noodle soup, canned, condensed	0.1 (0.1)	241	0.2
H18	frozen meal—salisbury steak with gravy	2.3 (0.2)	312	7.2	H40	tomato soup, canned, condensed	1.5 (0.7)	248	3.7
H20	frozen meal—turkey with gravy	5.3 (0.6)	312	16.5	H41	mushroom soup, canned, condensed	2.0 (0.3)	248	5.0
H22	macaroni and cheese, from box mix	5.3 (0.3)	200	11	H42	vegetable beef soup, canned, condensed	0.6 (0.2)	244	1.5
H24	spaghetti with tomato sauce, canned	0.7 (0.05)	250	1.8	H43	clam chowder, New England, canned, condensed	0.3 (0.1)	248	0.7
				I. Desserts					
I02	chocolate milkshake, fast food	0.2 (0.03)	283	0.6	I28	brownies, commercial	14 (1.3)	57	8.0
I04	vanilla ice cream	0.3 (0.02)	66	0.2	I30	sugar cookies, commercial	11 (0.5)	30	3.4
I10	fruit flavor sherbet	0.3 (0.02)	87	0.3	I32	chocolate chip cookies, commercial	10 (0.9)	30	3.0
I12	chocolate pudding, from instant mix	0.4 (0.03)	147	0.6	I34	sandwich cookies with creme filling, commercial	8.7 (0.6)	30	2.6
I14	popsicle, any flavor	<0.01 (<0.01)	75	<0.01	I36	apple pie, fresh/frozen, commercial	11 (1.1)	125	14
I16	chocolate cake with chocolate icing, commercial	13 (1.2)	64	8.4	I40	pumpkin pie, fresh/frozen, commercial	10 (0.01)	109	11
I18	yellow cake with white icing	8.5 (0.7)	64	5.4	I42	milk chocolate candy bar, plain	0.4 (0.05)	40	0.2
I20	chocolate snack cake with chocolate icing	5.7 (0.5)	50	2.9	I44	caramel candy	1.7 (0.3)	40	0.7
I24	sweet roll/danish, commercial	11 (0.8)	65	7.3	I46	suckers, any flavor	<0.01 (<0.01)	15	<0.01
I26	cake doughnuts with icing, any flavor	9.8 (0.4)	47	4.6	I48	gelatin dessert, any flavor	0.02 (<0.01)	120	0.02
				J. Snacks					
J02	potato chips	15 (3.8)	28	4.1	J06	popcorn, popped in oil	20 (1.5)	22	4.4
J04	corn chips	7.3 (0.3)	28	2.0	J08	pretzels, hard, salted, any shape	2.9 (0.4)	28	0.8
				K. Condiments and Sweeteners					
K02	tomato catsup	3.6 (0.4)	15	0.5	K14	jelly, any flavor	12 (1.1)	19	2.3
K06	white sugar, granulated	<0.01 (<0.01)	2	<0.01	K16	sweet cucumber pickles	23 (1.6)	28	6.3
K08	pancake syrup	<0.01 (<0.01)	80	<0.01	K18	dill cucumber pickles	13 (1.3)	28	3.7
K10	honey	<0.01 (<0.01)	21	<0.01	K20	yellow mustard	2.2 (0.1)	5	0.1
K12	chocolate syrup dessert topping	0.2 (0.03)	38	0.08	K22	black olives	1.4 (0.7)	15	0.2

Table 1 (Continued)

code	food name	phylloquinone content, mean (SD) (μg/100 g)	av serving size (g)	phylloquinone per serving (μg)	code	food name	phylloquinone content, mean (SD) (μg/100 g)	av serving size (g)	phylloquinone per serving (μg)
				L. Fats and Dressings					
L02	half and half	1.3 (0.3)	30	0.4	L16	French salad dressing, regular	51 (5.7)	29	15
L04	cream substitute, frozen	5.7 (0.6)	15	0.9	L18	Italian salad dressing, low calorie	2.9 (0.7)	29	0.8
L08	sour cream	1 (0.07)	30	0.3	L20	butter, regular (salted)	7.0 (1.3)	14	1.0
L10	white sauce, homemade	6.9 (1.1)	66	4.6	L22	margarine, stick, regular	33 (4.3)	14	4.6
L12	brown gravy, homemade	0.3 (0.04)	65	0.2	L24	olive/safflower oil	28 (1.0)	14	3.9
L14	mayonnaise, regular, bottled	41 (1.2)	14	5.8					
				M. Beverages					
M02	tap water	<0.01 (<0.01)	237	<0.01	M18	fruit drink, from powder	<0.01 (<0.01)	262	<0.01
M04	coffee, from ground beans	<0.01 (<0.01)	241	<0.01	M20	fruit drink, canned	0.02 (0.01)	248	0.05
M06	coffee, decaffeinated, from instant	0.02 (0.01)	241	0.05	M22	beer	<0.01 (<0.01)	238	<0.01
M08	tea, from tea bag	0.08 (0.02)	237	0.2	M24	martini	<0.01 (<0.01)	70	<0.01
M10	cola, carbonated beverage	0.02 (0.01)	246	0.05	M26	dry table wine	<0.01 (<0.01)	236	<0.01
M12	low-calorie cola, carbonated beverage	<0.01 (<0.01)	237	<0.01	M28	whiskey	<0.01 (<0.01)	42	<0.01
M16	lemonade, from frozen concentrate	0.06 (<0.01)	248	0.1					
				N. Infant and Junior Foods					
N02	milk-baked infant formula, low iron, ready-to-feed	13 (0.6)	30	4.0	N38	creamed spinach, strained/junior	292 (22)	113	330
N04	milk-baked infant formula, high iron, ready-to-feed	12 (0.2)	30	3.5	N40	carrots, strained/junior	5.8 (0.9)	113	6.6
N06	soy-based infant formula, ready-to-feed	16 (0.7)	30	4.7	N42	sweetpotatoes, strained/junior	1.0 (0.1)	113	1.1
N10	egg yolk, strained/junior	0.4 (0.06)	113	0.5	N44	green beans, strained/junior	26 (2.8)	113	29
N12	beef, strained/junior	1.7 (0.1)	113	1.9	N46	beets, strained/junior	0.1 (0.01)	113	0.1
N16	chicken, strained/junior	<0.01 (<0.01)	113	<0.01	N48	creamed corn, strained/junior	0.05 (0.01)	113	0.1
N18	rice infant cereal, instant, prepared with whole milk	0.3 (0.02)	113	0.3	N50	mixed vegetables, strained/junior	7.4 (0.6)	113	8.4
					N52	peas, strained/junior	17 (1.1)	113	19
N20	rice cereal, strained/junior	0.3 (0.02)	113	0.3	N54	vegetables and beef, strained/junior	4.1 (0.6)	113	4.6
N22	applesauce, strained/junior	1.3 (0.2)	113	1.5	N56	vegetables and chicken, strained/junior	3.5 (0.2)	113	4.0
N24	peaches, strained/junior	4.9 (0.07)	113	5.5	N58	vegetables and ham, strained/junior	1.6 (0.2)	113	1.8
N26	pears, strained/junior	4.3 (0.2)	113	4.9	N68	macaroni, tomatoes, and beef, strained/junior	1.7 (0.2)	113	1.9
N28	apple juice, strained	0.01 (<0.01)	124	0.01	N70	turkey and rice, strained/junior	4.2 (0.5)	113	4.7
N30	orange juice, strained	<0.01 (<0.01)	124	<0.01	N72	chicken and noodle dinner, strained/junior	0.9 (0.09)	113	1.0
N32	banana with tapioca, strained/junior	0.1 (0.01)	113	0.1	N74	split peas with vegetables and ham/bacon, strained/junior	3.0 (0.5)	113	3.4
N34	fruit dessert/pudding, strained/junior	0.5 (0.1)	113	0.6					
N36	custard pudding, strained/junior	<0.01 (<0.01)	113	<0.01	N76	teething biscuits	4.5 (0.3)	11	0.5

phylloquinone. Because the average serving size of many of these dishes exceeds 100 g, the absolute phylloquinone intake could be quite significant relative to the current daily Recommended Dietary Allowance of 0.5–1.0 μg/kg (NRC, 1989). This is particularly evident among the carryout meals such as the beef chow mein, taco/tostada, and fish sandwiches which contain 78, 28, and 26 μg of phylloquinone per average serving, respectively.

As a group, the milk and cheese items did not contain significant amounts of phylloquinone. The one exception was the low-fat, fruit-flavored yogurt that had unspecified types of fruit mixed in (6.8 μg of K_1/average serving). Although fleshy portions of fruit do not contain appreciable amounts of this vitamin, fruits with a high peel-to-flesh ratio, such as plums and grapes, do. It is not known if the drying process destroys the phylloquinone in fruits, as indicated by the corresponding low values for raisins and prunes in this study, but this should be an area of future investigation.

The beverages group, including carbonated, alcoholic, and brewed beverages, contained the lowest overall level of phylloquinone, with most of the beverages having concentrations below the lower limit of detection (0.01 μg of K_1/100 g). Although there have been several reports of brewed tea and coffee containing high levels of phylloquinone (Das et al., 1964; Stagg and Millin, 1974), other more recent researchers have reported negligible amounts (Booth et al., 1995; Ferland et al., 1992; Sakano et al., 1988), confirming the data presented here.

The infant and junior foods group had a wide range of phylloquinone values, which reflected the diversity of the food items within this group. The highest values corresponded to the green, leafy vegetables such as creamed spinach (292 μg of K_1/100 g of food), whereas the lower end of the range corresponded to fruit juices (below the limit of detection). These values for the infant and junior foods category are in agreement with the general distribution of phylloquinone values for the other food groups.

The FDA-TDS provided a unique opportunity to analyze representative, commonly consumed foods in the American diet for their phylloquinone content. From the food data now available for this nutrient, it is apparent that the two major sources of phylloquinone are leafy, green vegetables and certain plant oils. By analyzing foods in their ready-to-eat form, we were able to identify moderate sources of phylloquinone among foods that had previously been of low priority for phylloquinone analysis because of their low phylloquinone content in the raw form. The addition of phylloquinone-rich oils in the processing of many foods increased their potential contribution to the overall vitamin K nutriture. This was most evident among animal products, such as chicken and eggs, and root vegetables, such as potatoes. In contrast, food groups that are poor dietary contributors to vitamin K intake, such as roots, fleshy portions of fruits, fruit juices, and other beverages, will have low priority for future food analysis.

The phylloquinone food composition data from the FDA-TDS can now be applied to intake data generated from the 1987–1988 NFCS for the estimation of phylloquinone intake in various sectors of the American population as stratified by age and gender. In addition, these data expand and improve the quality and quantity of the phylloquinone food database and will facilitate the development of dietary tools for the evaluation of phylloquinone intake and its relationship to disease states such as osteoporosis and vascular disease.

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