Vitamin K Contents of Grains, Cereals, Fast-Food Breakfasts, and Baked Goods

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ABSTRACT: Accurate dietary assessment of vitamin K requires representative food composition data for specific geographical regions. The purpose of this study was to determine the contents of 3 different forms of vitamin K (phylloquinone [K1], 2′,3′-dihydrophylloquinone [dK], and menaquinone-4 [MK-4]) in representative grains, cereals, and baked goods, including breakfast foods, in the U.S. food supply. Samples were obtained as part of USDA's Natl. Food and Nutrient Analysis Program and analyzed by high-performance liquid chromatography (HPLC). Overall, breads, grains, and breakfast cereals were limited sources of K1 (range: nondetectable [ND] to 11.2 μg/100 g), with a wide range in dK (range: ND to 47.0 μg/100 g). In contrast, processed foods, such as fast-food breakfast sandwiches and baked goods, contain wide ranges of K1 (0.9 to 39.3 μg/100 g) and dK (ND to 72.2 μg/100 g). For any given food, K1 concentrations clustered within a narrow range, whereas dK concentrations had a wide range for a given food, suggestive of divergent use of hydrogenated oils in the manufacturing process. Low MK-4 concentrations (1.8 to 4.0 μg/100 g) were detected in meat- and cheese-containing breakfast foods and certain pie crusts. These data suggest that processed foods that contain K1-rich plant oils are a source of K1 and dK in the U.S. food supply.

Keywords: vitamin K, phylloquinone, cereals, grains, food composition

Introduction

Vitamin K is a fat-soluble vitamin, with a putative protective role in age-related bone loss and vascular calcification (Shearer 2000), in addition to its established role in blood coagulation. Historically, the predominant dietary form, phylloquinone, also known as vitamin K_1, was believed to be limited to green, leafy vegetables, animal livers, and certain plant oils (Booth and Suttie 1998). However, systematic sampling and analysis of representative foods for vitamin K have revealed a widespread distribution of vitamin K in the food supply (Booth and others 1995a; Bolton-Smith and others 2000). Likewise, there are multiple forms of vitamin K present in commonly consumed foods, including 2′,3′-dihydrophylloquinone, which is the product of commercial hydrogenation of phylloquinone-rich plant oils (Davidson and others 1996), and menaquinone-4 (MK-4), which is the product of tissue-specific conversion of phylloquinone or realkylation of menadione, a common synthetic form of vitamin K used in animal feed (Davidson and others 1998).

The current median dietary intakes for vitamin K are 90 and 120 μg/d for women and men, respectively (IOM 2001). Recent intake studies indicate that certain age groups in the United States and United Kingdom report average intakes below 90 μg/d (Booth and Suttie 1998; Thane and others 2002). Furthermore, patients taking coumarin-based oral anticoagulants are advised to maintain a stable dietary intake of vitamin K. However, accurate dietary assessment of vitamin K requires representative food composition data for specific geographical regions, with an emphasis on key foods currently consumed within that food supply. As part of an ongoing Natl. Food and Nutrient Analysis Program (NFNAP), aliquots of composited, homogenized foods that are representative of key foods consumed in the United States are being analyzed for multiple forms of vitamin K (Haytowitz and others 1996; Pehrsson and others 2000; Peterson and others 2002). Cereals and grains are considered poor dietary sources of vitamin K (Koivu and others 1998), although based on a limited number of samples analyzed in a previous study, processed cereals and grains in the form of baked goods may contain both phylloquinone and dihydrophylloquinone in some food supplies (Booth and others 1995b). Although baked products are not significant sources of vitamin K, they are frequently consumed and therefore, provide additional vitamin K to the diet. The purpose of this study was to determine the phylloquinone, dihydrophylloquinone, and MK-4 contents of representative grains, cereals, and baked goods, including breakfast foods, in the U.S. food supply.

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Materials and Methods

Food samples were obtained from the U.S. Dept. of Agriculture Nutrient Data Laboratory as part of the NFNAP (Haytowitz and others 1996; Pehrsson and others 2000; Peterson and others 2002). Samples were collected in 12 cities in the United States and composited to form either brand-specific or subnational composites as appropriate to the food item. This food sampling plan provides aliquots of composited, homogenized foods that are representative of key foods consumed in the United States. After purchase by agents at retail outlets around the United States, the samples were shipped to the Food Analysis Laboratory Control Center at Virginia Polytechnic Inst. and State Univ. in Blacksburg, Va., for the preparation of food samples and quality-control materials. Aliquots of the foods were shipped on dry ice to the Vitamin K Laboratory at Tufts Univ., Boston, Mass., and stored at –80 °C until analyzed. Vitamin K is stable under these conditions for a minimum of 2 y (unpublished data). All samples were analyzed within 6 mo of receipt.

All solvents used in sample extraction and chromatography were of high-performance liquid chromatography (HPLC)-grade

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(Fisher Scientific, Pittsburgh, Pa., U.S.A.). Phylloquinone, MK-4, zinc chloride, and sodium acetate were purchased from Sigma Chemical Co. (St. Louis, Mo., U.S.A.); zinc (–200 mesh) was purchased from Johnson Matthey Electronics (Ward Hill, Mass., U.S.A.); purified 2′, 3′-dihydrophylloquinone was a gift from J. Pyrek, Univ. of Kentucky Mass Spectrometry Facility; and the internal standard, $K_{1(25)}$, was purchased from GLSynthesis Inc. (Worcester, Mass., U.S.A.). Primary and secondary stock solutions of standards were diluted to known concentrations in methanol and characterized spectrophotometrically and chromatographically. Yellow light was used during extraction, purification, and analysis because vitamin K is sensitive to photo-oxidation.

The phylloquinone, MK-4, and dihydrophylloquinone contents of the food samples were determined using a modification of the procedure described elsewhere (Booth and Sadowski 1997; Peterson and others 2002). All samples were analyzed in duplicate (including extraction). If the CV of duplicates was greater than 15% (for samples with phylloquinone concentrations >5 μg/100 g) the assay was repeated. For samples containing <5 μg/100 g, the assay was repeated if the duplicate differed by greater than 0.75 μg/100 g. A control sample (consisting of an aliquot of baby food chicken vegetable dinner) was run with each batch of foods. A compilation of results from this sample over a 6-mo period gave a mean ± SD result of 2.6 ± 0.3 μg/100 g for K and 6.5 ± 0.5 μg/100 g for MK4. Over this same period, the average within-run CV for this sample was 8.3% for K and 6.7% for MK4. This method has a lower limit of detection (LOD) of 14 pg per injection (equivalent to 0.06 μg/100 g of sample); however, concentrations less than 0.2 μg/100 g were reported as not detectable. The sample (0.1 to 0.2 g) was weighed directly into a 50-mL polypropylene centrifuge tube. Ten (10) mL of water and an appropriate amount (equivalent to the approximate amount of phylloquinone projected for each sample) of internal standard was added followed by 15 mL of 2-propanol:hexane (3:2 v/v). The mixture was vortexed for 3 min and then further dispersed by sonication (continuous output at 50% duty cycle, output control 4 for 60 s) using a Branson Model 350 Sonifier Cell Disruptor with a 1/8-in tapered microtip (Branson Ultra Sonics Corp., Danbury, Conn., U.S.A.). Finally, the samples were vortexed for another 3 min. Phase separation was achieved by centrifugation at 1800 × *g* for 5 min. The upper (hexane) layer was aspirated into a glass culture tube and evaporated to dryness under reduced pressure in a centrifugal evaporator (Speed Vac SC210A, Savant Instruments, Farmingdale, N.Y., U.S.A.). The residues were reconstituted with hexane.

All hexane solutions were further processed by solid phase extraction (SPE) on 500 mg Bond Elut silica columns (Varian Inc., Walnut Creek, Calif., U.S.A.). Each column was preconditioned by washing with 4 mL of hexane:diethyl ether (96.5:3.5 v/v) followed by 4 mL of hexane. After the sample was applied to the column, it was washed with 4 mL of hexane. The fraction that contained phylloquinone was eluted with an 8-mL wash of hexane:diethyl ether (96.5:3.5 v/v). The eluate was evaporated to dryness in the centrifugal evaporator. The residue was reconstituted initially with 30 μL of methylene chloride followed by 170 μL of methanol with 10 m*M* $ZnCl_2$, 5 m*M* acetic acid, and 5 m*M* sodium acetate (5.5 mL of an aqueous solution of 2.0 *M* $ZnCl_2$, 1.0 *M* acetic acid, and 1.0 *M* sodium acetate was added to methanol to give a final volume of 1.0 L). The reconstituted residues were transferred to amber sample vials with glass inserts (300 μL) (Chromacol Ltd., distributed by SUN-SRi, Duluth, Ga., U.S.A.) and sealed with crimp caps. All vials were centrifuged for 5 min at 1800 × *g* before placing on the HPLC instrument.

HPLC analytical conditions

The chromatographic system used to determine concentrations of menaquinone-4, phylloquinone and dihydrophylloquinone consisted of a 2695 Separations Module (Waters, Milford, Mass., U.S.A.) equipped with a vacuum degasser and a model RF-10AXL Shimadzu Fluorescence Detector (Shimadzu Instruments, Columbia, Md., U.S.A.). The analytical column (150 × 3 mm) was packed with 5-micron BDS Hypersil C_{18} (Keystone Scientific, Bellefonte, Pa., U.S.A.). Fluorescent derivatives of the injected quinones were produced on-line using a post column reactor (2.0 × 50 mm) dry packed with zinc (–200 mesh). The excitation wavelength was 244 nm and the emission wavelength was 430 nm. The mobile phase consists of 2 solvents. Solvent A is methanol with 10 m*M* $ZnCl_2$, 5 m*M* acetic acid, and 5 m*M* sodium acetate prepared as described previously. Solvent B is methylene chloride. The 2695 was programmed to do the following gradient elution procedure: (1) pump a 90:10 (A:B) mixture at 0.60 mL/min from injection for the first 11.50 min; (2) at 11.50 min, change the flow rate to 0.80 mL/min and the composition to 70:30 (A:B); (3) at 19.50 min, change the composition to 90:10 (A:B); (4) at 23.50 min, change the flow rate to 0.60 mL/min; and (5) at 24.0 min, end the cycle.

Standard curves were prepared from each calibrator injection. The fluorescence responses for MK4, phylloquinone, dihydrophylloquinone, and $K_{1(25)}$ are linear with the slope of the lines bisecting zero. Therefore, we routinely performed single-point calibration, forcing the slope of the line through zero. Quantitation was achieved by direct comparison of peak area ratios (MK4, phylloquinone or dihydrophylloquinone to $K_{1(25)}$) generated from the calibration standard to those generated by the sample. Peak integration and sample concentration calculations were performed using Waters Millennium[32] software, version 3.20.

Results and Discussion

Phylloquinone and dihydrophylloquinone concentrations of bread, rice, and pasta are presented in Table 1. No MK-4 was detected in these samples, which was expected, given that MK-4 is limited to tissues of animal origin (Booth and Suttie 1998). Concentrations of phylloquinone varied from a nondetectable (ND) amount in rice, pasta, bagels, and corn tortillas to a high of 46.0 μg/100 g in seasoned bread crumbs. Seasoned bread crumbs had higher concentrations of phylloquinone compared with the plain bread crumbs, presumably due to the dried herbs that they contain, which are rich in phylloquinone (Booth and Suttie 1998). Other breads had much lower phylloquinone concentrations (0.6 to 11.2 μg/100 g). Dihydrophylloquinone concentrations ranged from ND for bleached flour, spaghetti, seasoned bread crumbs, plain English muffins, bagels, and French bread to 47.0 μg/100 g in refrigerated biscuits. There were no significant differences in phylloquinone or dihydrophylloquinone concentrations between unprepared and toasted breads or muffins. These findings are consistent with previously reported phylloquinone and dihydrophylloquinone concentrations in grains and cereals (Booth and others 1995a; Booth and others 1995b; Booth and others 1996; Koivu and others 1998; Bolton-Smith and others 2000). In contrast, wheat and white breads had higher phylloquinone concentrations in this study compared with previous reports (Booth and others 1995a). All samples of corn taco shells and refrigerated biscuits had relatively high concentrations of dihydrophylloquinone compared with their respective phylloquinone contents due to the addition of hydrogenated oils during the manufacturing process. This may change in the future with reformulations designed to remove v:*trans* fatty acids from food products. Corn itself has negligible amounts of phylloquinone, as supported by ND amounts of phylloquinone in the corn tortillas.

Phylloquinone, dihydrophylloquinone, and menaquinone-4

Table 1—Phylloquinone (K1) and dihydrophylloquinone (dK) contents of bread, rice, and pasta

		K1 (μg/100 g)			dK (μg/100 g)		
Food	N	Mean	SD	Range	Mean	SD	Range
Bagels, plain, unprepared, and toasted	11	0.9	0.3	0.4 to 1.2	0.7	0.5	ND[a] to 1.4
Breads							
Dinner rolls	6	11.2	1.8	9.5 to 14.4	3.0	1.2	1.3 to 4.7
French	4	0.6	0.7	ND to 1.3	ND	—[b]	—
Hamburger/hot dog rolls	2	4.5	—	4.5	1.2	—	1.0 to 1.3
Refrigerated biscuits	12	6.4	2.0	4.6 to 11.7	47.0	5.7	39.4 to 59.7
Wheat	9	6.7	2.3	4.5 to 11.0	0.8	2.1	ND to 2.2
White	2	3.8	—	3.4 to 4.1	0.3	—	ND to 0.5
Bread crumbs							
Plain	1	6.6	—	—	1.1	—	—
Seasoned	1	46.0	—	—	ND	—	—
English muffins							
Plain, unprepared and toasted	4	1.3	0.4	0.9 to 1.7	0.2	0.2	ND to 0.4
Cinnamon raisin, unprepared and toasted	4	2.5	0.6	2.0 to 3.1	0.6	0.6	ND to 1.1
Flour, bleached, all-purpose	1	ND	—	—	ND	—	—
Long grain rice, unprepared and cooked	7	ND	—	—	0.2	0.5	ND to 1.3
Pasta							
Elbow macaroni	1	ND	—	—	1.4	—	—
Spaghetti, unprepared and cooked	4	ND	—	—	ND	—	—
Taco shells, corn, hard, ready to eat	3	8.6	4.7	3.4 to 12.4	35.2	13.6	22.7 to 49.7
Tortillas, refrigerated							
Corn	2	ND	—	—	1.7	—	1.4 to 1.9
Flour	2	3.5	—	2.6 to 4.3	8.3	—	7.9 to 8.6

[a]ND = nondetectable.
[b]For food items with 2 or less samples, no standard deviation was reported.

Table 2—Phylloquinone (K1), dihydrophylloquinone (dK), and menaquinone-4 (MK-4) contents of breakfast foods, fast food breakfasts, cereals, and cereal bars

		K1 (μg/100 g)			dK (μg/100 g)			MK4 (μg/100 g)		
Food	N	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Breakfast cereal										
All-bran	1	5.2	—[a]	—	ND[b]	—	—	ND	—	—
Natural granola, oats, and honey	1	4.2	—	—	1.7	—	—	ND	—	—
Ready to eat, various types	10	0.9	0.7	ND to 1.9	ND	—	ND to 0.6	ND	—	—
Breakfast items, fast food										
Bacon and egg	5	9.6	1.4	7.4 to 11.3	4.7	3.3	1.4 to 10.0	1.8	0.3	1.5 to 2.1
Bacon, egg, and cheese	8	6.7	3.4	1.8 to 12.8	13.2	9.5	1.1 to 26.6	2.0	0.5	1.3 to 3.0
Egg and cheese[a]	11	6.5	4.6	ND to 11.8	4.5	3.8	ND to 9.3	2.1	0.5	1.6 to 3.0
French toast sticks	4	14.6	0.7	13.7 to 15.3	27.8	3.7	23.2 to 32.3	ND	—	—
Ham, egg and cheese	4	3.0	0.7	2.3 to 3.9	ND	—	—	1.9	0.3	1.5 to 2.2
Pancakes with sausage	4	10.9	2.0	8.4 to 13.0	ND	—	—	ND	—	—
Sausage	12	3.5	1.7	1.9 to 6.9	11.7	13.4	ND to 32.3	3.0	0.6	2.0 to 3.9
Sausage and egg	8	4.4	2.0	1.3 to 5.8	9.0	9.8	ND to 21.1	3.1	0.7	1.8 to 3.9
Sausage and cheese	4	6.5	0.7	5.8 to 7.4	11.6	0.6	10.8 to 12.2	3.3	0.6	2.8 to 3.9
Sausage, egg and cheese	4	9.6	0.7	8.9 to 10.5	8.9	0.7	7.9 to 9.4	4.0	0.4	3.5 to 4.4
Spanish omelet	3	2.8	0.7	2.1 to 3.4	ND	—	ND to 0.5	2.9	0.3	2.5 to 3.1
Steak, egg, and cheese	4	3.5	1.0	2.2 to 4.4	0.6	0.8	ND to 1.7	2.7	0.9	1.9 to 3.9
Cereal bars	6	21.1	9.6	11.6 to 33.1	11.4	10.18	ND to 25.2	ND	—	—
Corn grits, uncooked and cooked	27	ND	—	—	ND	—	—	ND	—	—
Cream of wheat, uncooked and cooked	28	ND	—	—	ND	—	—	ND	—	—
Oatmeal										
Cooked	12	0.4	0.1	0.2 to 0.6	ND	—	—	ND	—	—
Uncooked	6	2.0	0.3	1.7 to 2.5	ND	—	—	ND	—	—
Pancakes, buttermilk (prepared from mix)	3	6.4	1.1	5.3 to 7.5	3.7	1.1	2.7 to 4.8	ND	—	—
Toaster pastries, strawberry, frosted and plain	10	6.1	1.4	4.7 to 8.3	23.0	5.0	15.7 to 29.1	ND	—	—
Waffles, frozen, uncooked, and toasted										
Buttermilk	3	11.3	1.1	10.5 to 12.5	18.5	2.0	16.9 to 20.8	ND	—	—
Regular	3	7.6	0.7	6.8 to 7.9	26.0	8.4	19.6 to 35.5	ND	—	—

[a]For food items with 2 or less samples, no standard deviation was reported.
[b]ND = nondetectable.

Table 3—Phylloquinone, dihydrophylloquinone, and menaquinone-4 contents of baked goods

		K1 (μg/100 g)			dK (μg/100 g)			MK4 (μg/100 g)		
Food	N	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Cake mixes										
Chocolate Devils food	2	4.7	—[a]	—	4.5	—	—	ND	—	—
Commodity bakery mix	1	7.9	—	—	16.3	—	—	ND	—	—
Cinnamon buns	4	14.0	0.9	12.8 to 14.9	22.8	2.4	0.7 to 1.8	ND	—	—
Cookies, chocolate chip	4	15.3	9.4	8.0 to 29.1	72.2	12.1	54.3 to 79.7	ND	—	—
Cupcakes, chocolate	2	10.7	—	4.1—17.2	20.4	—	2.0 to 38.7	ND	—	—
Doughnuts										
Cake, chocolate covered	2	7.9	—	7.0 to 8.8	20.2	—	1.9 to 38.4	ND	—	—
Cake, plain	1	10.5	—	—	41.1	—	—	ND	—	—
Glazed, plain	2	11.5	—	9.4 to 13.6	34.4	—	24.5 to 44.2	ND	—	—
Mini cake w/ powdered sugar	1	8.9	—	—	4.4	—	—	ND	—	—
Muffins, blueberry	2	39.3	—	32.6 to 45.9	1.0	—	ND[b] to 1.9	ND	—	—
Pies										
Apple, frozen, unprepared and prepared	9	15.2	2.2	11.8 to 17.9	38.0	5.4	29.5 to 46.7	0.6	0.5	ND to 1.1
Pecan, frozen, prepared	2	15.5	—	15.2 to 15.8	28.5	—	25.6 to 31.4	0.2	—	ND to 0.5
Pumpkin, frozen, prepared	2	13.3	—	12.8 to 13.7	23.0	—	21.8 to 24.1	ND	—	—
Pie crusts										
Regular fat, refrigerated or frozen, as purchased or baked	14	5.9	11.8	ND to 43.4	33.2	44.1	ND to 132	2.2	1.8	ND to 5.1
Graham cracker type, prepared	3	21.8	6.1	14.9 to 25.2	69.0	38.4	35.4 to 111	ND	—	—
Chocolate type, prepared	3	18.2	3.9	15.0 to 22.5	64.1	15.4	47.4 to 77.6	0.5	0.4	ND to 0.8

[a]For food items with 2 or less samples, no standard deviation was reported.
[b]ND = nondetectable.

concentrations in breakfast foods, cereals, and cereal bars are presented in Table 2. To the best of our knowledge, this is the 1st report of MK-4 in breakfast foods. Foods samples containing detectable amounts of menaquinone-4 varied in concentration from 1.8 μg/100 g in bacon and egg breakfast sandwiches to 4.0 μg/100 g in sausage, egg, and cheese breakfast sandwiches from fast food restaurants. Phylloquinone concentrations in these breakfast foods ranged from ND for cream of wheat and corn grits to 21.1 μg/100 g in cereal bars. The low phylloquinone concentrations in the cereals (Booth and others 1993; Booth and others 1995a; Bolton-Smith and others 2000) and uncooked oatmeal support previously reported data. The uncooked oatmeal has a higher concentration of phylloquinone than the cooked oatmeal due to the dilution effect created by the addition of water during preparation. In contrast, cream of wheat and corn grits had no detectable amount of any form of vitamin K, regardless of the preparation. The all-bran and natural granola cereals had much higher phylloquinone concentrations than the other various breakfast cereals. This may be an indication of the dried fruits and nuts or bran that they contain (Booth and others 1995a). Ham, egg, and cheese breakfast sandwiches from fast food restaurants had similar amounts of phylloquinone compared with previous results (Booth and others 1995a; Booth and others 1996); however, no dihydrophylloquinone was detected in this study, in contrast to previous reports (Booth and others 1996). With few exceptions, the phylloquinone concentrations clustered within a narrow range for a given food. In contrast, dihydrophylloquinone concentrations had a wide range for given food, suggestive of divergent use and amount of hydrogenated oils used in the manufacturing process. With reformulations designed to remove hydrogenated oils from food products, the dihydrophylloquinone concentrations of these foods may decrease in the future.

Table 3 contains phylloquinone and dihydrophylloquinone data for baked goods. Phylloquinone concentrations ranged from 4.7 μg/100 g in devil's food cake mix to 39.3 μg/100 g in blueberry muffins. Previous reports for blueberry muffins had lower phylloquinone and dihydrophylloquinone concentrations (Booth and others 1996). In this study, blueberry muffins had the least amount of dihydrophylloquinone of the baked goods, in contrast to chocolate chip cookies, with 72.2μg of dihydrophylloquinone/100 g cookie. The vitamin K contents of various doughnuts analyzed in this study were consistent with previous reports (Booth and others 1995a). The phylloquinone and dihydrophylloquinone concentrations of pie crusts had a wide range, suggestive of divergent use and amount of hydrogenated phylloquinone-rich oils used in the manufacturing process. In contrast, the frozen pies had a narrow range for any given type. Preparation did not change the phylloquinone or dihydrophylloquinone content of these foods. Of interest was the menaquinone-4 present in some of the pie crusts that otherwise contained no other form of vitamin K. Further examination of the ingredients indicated that these crusts were made primarily of lard, which contains products of animal origin. To the best of our knowledge, this is the 1st report of menaquinone-4 in a baked good. However, relative to the phylloquinone and dihydrophylloquinone contents of pie crusts made of vegetable oil-based shortening, the menaquinone-4 content of those made with lard was low.

Overall, breads, grains, and breakfast cereals are generally limited sources of phylloquinone or dihydrophylloquinone, with a narrow range for any given food, consistent with earlier assumptions (Booth and Suttie 1998). In contrast, processed foods, such as fast-food breakfast sandwiches, cereal bars, pancakes, waffles, and baked goods, do contain vitamin K, with wide ranges of phylloquinone and dihydrophylloquinone associated with a given food. There are limited data available regarding the biological activity of dihydrophylloquinone, although 1 human study suggests that it may not be equivalent to that of the parent form, phylloquinone (Booth and others 2001). However, dihydrophylloquinone does appear to function as a cofactor for the vitamin K–dependent carboxylase, and has been shown to support vitamin K–dependent carboxylation of the vitamin K–dependent proteins involved in coagulation. Therefore, these dietary sources of dihydrophylloquinone are of importance to health professionals involved in dietary counseling of vitamin K for patients on coumadin, or other coumarin-based oral anticoagulants. In meat-containing breakfast foods and pie crusts that contained MK-4, the content was low relative to phylloquinone and dihydrophylloquinone. Although a recent observational study (Geleijnse and others 2004) indicated that total menaquinone intakes, including MK-4, of >33 μg/d conferred a protective effect on incidence of coronary heart disease, the associations between MK-4 intakes and physiological outcomes are still relatively unknown. Furthermore, there are few studies assessing usual MK-4 intakes, primarily because of the paucity of available MK-4 food composition data.

Conclusions

Breads, rice, and pastas were overall poor sources of phyllo quinone and dihydrophylloquinone. Furthermore, there were no detectable levels of MK-4. The breakfast foods comprising mostly grains also had very low phylloquinone contents. Comparatively, those processed foods that contained oils, such as breakfast sandwiches, pancakes, waffles, and French toast sticks, had much higher concentrations of both phylloquinone and dihydrophylloquinone. Other breakfast foods, such as cereal bars, and baked goods were also dietary sources of vitamin K, with wide ranges measured for a given food. The breakfast sandwiches that contained meats also contained menaquinone-4. Collectively these data suggest that processed foods that contain phylloquinone-rich plant oils are an unexpected source of both phylloquinone and dihydrophylloquinone. It is currently not known the extent to which these foods contribute to dietary intakes in the United States adult population, nor whether these foods should be accounted for in dietary counseling of patients on the vitamin K antagonist, coumadin.

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