Vitamin K content of nuts and fruits in the US diet

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ABSTRACT

Assessment of vitamin K dietary intakes has been limited by incomplete vitamin K food composition data for the US food supply. The phylloquinone (vitamin K_1) concentrations of nuts (n=76) and fruits (n=215) were determined by high-performance liquid chromatography. Each sample represented a composite of units obtained from 12 to 24 outlets, which provided geographic representation of the US food supply. With the exception of pine nuts and cashews, which contain 53.9 and 34.8 μg of phylloquinone per 100 g of nut, respectively, nuts are not important dietary sources of vitamin K. Similarly, most fruits are not important sources of vitamin K, with the exception of some berries, green fruits, and prunes. Menu planning for patients on warfarin can include a healthy diet including fruits and nuts without compromising the stability of their oral anticoagulation therapy. *J Am Diet Assoc. 2003;103:1650-1652.*

Vitamin K is an essential cofactor for the conversion of glutamic acid (Glu) to gamma-carboxyglutamic acid (Gla) residues in vitamin-K–dependent proteins, including hemostasis factors II, VII, IX, X, and proteins C and S (1). Warfarin, an oral anticoagulant prescribed for primary and secondary prevention of thromboembolic disease, interrupts the normal recycling of vitamin K in the liver. However, increased amounts of vitamin K consumed in the diet can reverse the anticoagulation effect of warfarin by acting through an alternate enzymatic pathway (2). Although a constant dietary vitamin K intake is recommended to promote stable oral anticoagulation, attaining a stable intake may be difficult given the limited food composition data available for this vitamin (3). This can be particularly problematic when designing diets that meet the United States Department of Agriculture (USDA) Dietary Guidelines (4), which recommend healthy eating patterns, including consumption of nuts and fruits.

Since the publication of a revised USDA provisional table for phylloquinone (vitamin K_1) (5), this nutrient has been incorporated into a number of food composition databases in the United States (3) and several European nations (6,7). Despite these advances, there are still weaknesses that exist in the food composition data, including a limited number of foods analyzed and poor geographic and seasonal representation. To expand and improve the US food composition database for all nutrients, the National Food and Nutrient Analysis Program initiated an integrated system for identifying foods and nutrients, food sampling, and chemical analysis in 1997 (8). Approximately 1,000 foods were identified as being important contributors of nutrients to the US food supply, including nuts and fruits. The goal of this study was to provide accurate and comprehensive vitamin K food composition data for nuts and fruits.

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0002-8223/03/10312-0010$30.00/0

doi: 10.1016/j.jada.2003.09.028

METHODS

Food samples used in this study were obtained from the USDA Nutrient Data Laboratory as part of the National Food and Nutrient Analysis Program, which has been described elsewhere (8). Fruits and nuts were sampled in 12 locations at two different times, referred to as pass 1 and pass 2. Samples were homogenized and a composite was made to create four regional samples for each pass. These samples were processed at the Food Analysis Laboratory Control Center located at Virginia Polytechnic Institute and State University, Blacksburg, VA, and shipped frozen to the Vitamin K Laboratory at Tufts University, Boston, MA, where they were stored at −80°C until analysis.

Two forms of vitamin K, phylloquinone and 2′,3′-dihydrophylloquinone, were analyzed using a reversed-phase high-performance liquid chromatography procedure described elsewhere (9,10). All foods were processed with an initial hexane extraction, followed by solid phase extraction on silica columns. Nut samples also required a second solid-phase extraction on C_{18} columns, as described elsewhere (10), because of their higher lipid content compared with fruit samples.

All samples were analyzed in duplicate, so reported values for individual samples represent the mean of the duplicates. If the coefficient of variation was greater than 15%, the assay was repeated, except in samples with phylloquinone concentrations of <5 μg per 100 g of sample. A control of baby food peaches was run in duplicate with each batch of foods. The high-performance liquid chromatography method had a lower limit of detection of 14 pg per injection (20 to 150 μL per injection, depending on the concentration of the sam-

Table 1
Phylloquinone content of nuts in the US food supply

Food	N	Phylloquinone (μg/100 g of nut)		
		Mean	SD	Range (minimum to maximum)
Almonds	8	ND[a]	ND[a]	. . .
Brazil nuts	7	ND[a]	ND[a]	. . .
Cashews	8	34.8	16.7	19.4-64.3
Hazelnuts	8	14.2	4.2	8.7-20.7
Macadamias	4	ND[a]	ND[a]	. . .
Peanuts	4	ND[a]	ND[a]	. . .
Peanut butter, creamy	4	0.4	0.8	ND-1.5
Peanut butter, crunchy	2	0.8	. . .[b]	0.4-0.7
Pecans	8	3.5	1.5	2.0-6.4
Pine nuts	7	53.9	16.4	33.4-73.7
Pistachios	8	13.2	1.6	10.1-15.1
Walnuts	8	2.4	1.4	1.0-4.6

[a]Below the limit of assay detection.
[b]No SD is reported when fewer than three samples of a given food were analyzed.

ple), which is equivalent to 0.006 μg per 100 g of sample.

RESULTS AND DISCUSSION

The phylloquinone content of nuts ranged from below the limit of detection to 73.7 μg/100 g, depending on the nut (Table 1). In comparison, the published phylloquinone content of green, leafy vegetables range from 70 to 1,220 μg/100 g (5). There were no systematic regional or seasonal differences observed in phylloquinone content among the nuts sampled, so the data were combined by nut type and pass number. To the best of our knowledge, this is the first report on the phylloquinone content of nuts with the exception of peanuts (5,7) and pistachio nuts (5). Overall, nuts do not contain appreciable amounts of phylloquinone. In previous studies (5,7), peanuts were reported to contain 0.2 to 0.4 μg of phylloquinone per 100 g of nut, which is comparable to the nondetectable levels reported in this study. Pistachio nuts were previously reported to contain 70 μg per 100 g of nut (5), which is higher than the 13.2 μg/100 g reported in this study. All nuts were also analyzed for 2′,3′-dihydrophylloquinone content and found to have nondetectable levels (data not shown). This was an expected finding because dihydrophylloquinone is a by-product of hydrogenation of phylloquinone-rich oils (11).

Reported nut consumption is low in the United States; most adults consume less than 3 to 5 g of nuts on a daily basis (12). Given that the recommended dietary vitamin K intake for healthy adults is 90 to 120 μg per day (13), and 8 of 12 types of nuts analyzed in this study contained $<$5 μg/100 g, nuts are not an important contributor to dietary vitamin K. However, certain individuals may increase their vitamin K intake in response to the growing public interest in the association between high dietary intakes of vitamin K and low risk of hip fracture (13). In these individuals, consumption of certain nuts, such as pine nuts and cashews, may be sufficiently high in some individuals to create an unexpected dietary source of vitamin K. For this reason, health care professionals should be aware of the potential contribution of large quantities of these nuts to vitamin K intake when counseling patients on the oral anticoagulant warfarin. Conversely, consumption of other nuts, such as walnuts, which are low in vitamin K, can be promoted for their reported health benefits (14) in these patients.

The phylloquinone contents of fruits are presented in Table 2. No systematic seasonal or regional differences in phylloquinone concentration were found in the fruits analyzed, so data were combined across regions and passes. All fruits were also analyzed for dihydrophylloquinone content, but were found to contain none (data not shown). Compared with previous studies, the phylloquinone content of several fruits (grapes, prunes, kiwifruit, fruit cocktail) reported in this study are higher than those previously reported in the USDA Provisional Table (5), but are consistent with the UK database (7) and a Finnish study (15). However, this is the first report of most of the fruits presented, and species differences preclude extensive comparison with the European studies.

The mean vegetable and fruit intake among US adults is approximately four servings per day (16), which is less than the five to seven daily servings of fruits and vegetables recommended in the USDA-Department of Health and Human Services Dietary Guidelines (4). Similar to nuts, most fruits are not potentially rich sources of phylloquinone, especially citrus fruits, because of low usual fruit consumption coupled with low phylloquinone content. However, exceptions exist, including prunes, kiwifruit, avocado, blackberries, blueberries, grapes, and figs, the mean phylloquinone content of which range from 15.6 to 59.5 μg per 100 g of fruit. Avocados have been identified as a potential dietary source of overcoagulation among patients on oral anticoagulants (17). In the provisional table, avocado was reported to contain approximately 40 μg of phylloquinone per 100 g of fruit (5), a concentration that is twice that of the concentration reported in this study and the Finnish study (15). Although avocados have one of the higher phylloquinone contents of fruits, it is unlikely that the amount of phylloquinone consumed would be enough to account for their reported interaction with stability of oral anticoagulants. In contrast, certain berries may be an unexpected dietary source of phylloquinone given their seasonal consumption. Consistent with previous reports, there was a higher phylloquinone concentration reported when apples were analyzed with the peel compared with without peel (5,7).

APPLICATIONS

- Some nuts, such as pine nuts and cashews, contain appreciable amounts of vitamin K, which if consumed in large quantities may create a potential dietary interaction with oral anticoagulants. Some berries, such as blackberries and blueberries; green fruits, such as kiwifruit; and prunes may also contribute to increased dietary vitamin K intakes. In contrast, other nuts and fruits are not important dietary sources of vitamin K. The data from this study will assist dietitians in counseling patients using the oral anticoagulant warfarin so that patients can consume a healthy diet including fruits and nuts without compromising the stability of their oral anticoagulation therapy.

Table 2
Phylloquinone content of fruits in the US food supply

Food	N	Phylloquinone (μg/100 g of fruit)		
		Mean	SD	Range (minimum to maximum)
Fruits fresh and canned				
Apples				
Fugi	4	1.0	0.1	0.9-1.1
Gala	4	1.3	0.1	1.2-1.5
Golden delicious				
With peel	2	1.6	. . .[a]	1.6-1.6
Without peel	2	0.7	. . .[a]	0.6-0.7
Granny Smith	4	3.2	0.8	2.6-4.3
Red delicious				
With peel	2	2.4	. . .[a]	2.2-2.5
Without peel	2	0.6	. . .[a]	0.6-0.6
Avocado	8	21.0	4.4	15.7-27.0
Bananas	4	0.7	0.3	0.5-1.0
Berries				
Blackberries	5	19.8	4.3	14.7-25.1
Blueberries	8	19.3	4.3	14.7-27.2
Cranberries	4	5.1	0.9	4.3-6.4
Raspberries	6	7.8	1.7	6.2-9.9
Strawberries	8	2.3	0.9	1.6-4.1
Cherries	4	2.7	1.1	1.8-4.0
Fruit cocktail, canned	2	3.8	. . .[a]	2.9-4.8
Grapefruit, red	8	ND[b]	ND[b]	. . .
Grapes, red and green	4	16.1	1.9	13.8-18.1
Kiwifruit	8	41.0	6.3	33.9-50.3
Melons				
Cantaloupe	8	2.5	0.8	1.6-4.0
Honeydew	8	3.7	1.3	2.7-6.1
Watermelon	8	0.1	0.1	0.1-0.1
Nectarines	8	2.2	0.5	1.3-2.8
Oranges				
Juice:				
Concentrate	2	0.1	. . .[a]	0.1-0.1
Refrigerated	2	0.1	. . .[a]	0.1-0.1
Navel	8	0.1	0.1	0.1-0.1
Peaches				
Fresh	8	3.8	1.1	2.5-5.7
Canned, solids	3	2.4	0.2	2.3-2.7
Canned, liquid	3	ND[b]	ND[b]	. . .
Pears				
Bartlett	4	3.8	1.5	2.2-5.0
Bosc	4	5.1	1.9	3.6-7.8
Green Anjou	4	4.3	0.6	3.8-5.1
Red Anjou	4	4.9	0.9	3.7-5.7
Pineapple	10	0.7	0.3	0.2-1.2
Plums	7	5.4	1.2	4.4-7.9
Dried fruits				
Dates	10	2.7	0.4	2.1-3.4
Dried apricots	2	2.8	. . .[a]	2.3-3.3
Figs	8	15.6	3.1	11.4-20.0
Prunes	8	59.5	5.0	51.1-68.1
Raisins	8	4.3	1.5	2.9-7.3

[a]No SD is reported when fewer than three samples of a given food were analyzed.
[b]Below the limit of assay detection.

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This material is based on work supported by federal funds from the US Department of Agriculture, Agricultural Research Service, under Cooperative Agreement No. 58-1950-001 and the National Heart Lung and Blood Institute, National Institutes of Health Agreement No. Y1-HV-8116-11. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the investigators, and do not necessarily reflect the views of the US Department of Agriculture.