

Phylloquinone (vitamin K₁) intakes and food sources in 18–64-year-old Irish adults

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Dietary vitamin K₁ (phylloquinone) levels that are sufficient to maintain normal blood coagulation may be sub-optimal for bone, and habitual low dietary intakes of vitamin K may have an adverse effect on bone health. The objective of the present study was to measure the intake and adequacy of phylloquinone intake and the contribution of foods to phylloquinone intake in a nationally representative sample of Irish adults. The North/South Ireland Food Consumption Survey database was used, which contains data collected using a 7 d food diary in a randomly selected sample of Irish adults aged 18–64 years (*n* 1379; 662 men and 717 women). Phylloquinone intakes were estimated using recently compiled food composition data for phylloquinone. The mean daily intake of phylloquinone from food sources was 79 (SD 44) µg. Intakes were significantly higher (*P* < 0.001) in men than in women at levels of 84 and 75 µg/d. The main contributors to phylloquinone intakes were vegetables (48%), particularly green vegetables (26%). Potatoes (including chipped and fried potatoes), dairy products and fat spreads contributed 10% each and meat contributed 8%. In men, social class and smoking status influenced phylloquinone intakes. Of the population, 52% had phylloquinone intakes below 1 µg/kg body weight and only 17% of men and 27% of women met the US adequate intakes of 120 and 90 µg/d, respectively. The present study shows that habitual phylloquinone intakes in Irish adults are low, which may have implications for bone health.

Phylloquinone intake: Ireland: Food consumption survey: 7 d Food record: Bone health

Compounds with vitamin K activity have a common 2-methyl-1,4-naphthoquinone ring but differ in the structure of the side chain at the 3-position (Ferland, 2001). Naturally occurring K vitamins are traditionally classified into two groups according to whether they are synthesised by plants or bacteria (Suttie, 1992). Vitamin K₁ (phylloquinone; 2-methyl-3-phytyl-1,4-naphthoquinone) is synthesised in plants (especially green plants) and represents the main source of dietary vitamin K in Western countries (Binkley & Suttie, 1995). Vitamin K₂, or menaquinones (2-methyl-1,4-naphthoquinones), are produced by bacteria and form a family of compounds with an unsaturated isoprenyl side chain of various lengths at the 3-position (Suttie, 1995). Menaquinones have a more restricted distribution in the diet, with nutritionally significant amounts occurring only in some meat, liver and certain fermented dairy products, such as cheese and curd cheeses (Schurgers *et al.* 1999). Colonic microflora also produce vitamin K₂ (Collins & Jones, 1981; Bentley & Meganathan, 1982), but the colonic absorption of these is probably very poor and, therefore, bacterial synthesis of vitamin K₂ only represents a minor source of vitamin K in human nutrition

(for reviews, see Lipsky, 1994; Suttie, 1995). Nonetheless, human liver can contain up to ten times as much vitamin K as a mixture of menaquinones than phylloquinone (Institute of Medicine, 2001).

The function of vitamin K is to serve as a cofactor for the vitamin K-dependent carboxylase, a microsomal enzyme that facilitates the post-translational conversion of glutamyl to γ -carboxyglutamyl residues (Esmon *et al.* 1975). Its classic role in this respect involves the synthesis of several coagulation factors, including plasma procoagulants, prothrombin (factor II) and factors VII, IX and X and anticoagulants (proteins C and S) (Shearer, 1990, 2000; Institute of Medicine, 2001). The maintenance of plasma prothrombin concentrations was the basis for the recommended dietary intake value of 1 µg/kg body weight per d, set by the National Research Council (1989) in the USA and by the Department of Health (1991) in the UK. More recently, the identification of γ -carboxyglutamyl-containing proteins in bone, notably osteocalcin and matrix γ -carboxyglutamyl protein, has generated much interest in the role of vitamin K in bone metabolism and bone health (Binkley & Suttie, 1995; Vermeer *et al.*

1995; for reviews, see Weber, 2001; Institute of Medicine, 2001). Furthermore, it has been suggested that dietary vitamin K levels that are sufficient to maintain normal blood coagulation may be sub-optimal for bone health (Kohlmeier *et al.* 1996; Vermeer *et al.* 1996; Sokoll *et al.* 1997).

Beside its role in bone health, there is also growing interest in the possible role of vitamin K in atherosclerosis (Jie *et al.* 1995; Shearer, 2000; Institute of Medicine, 2001) and cognitive function (Rambeck & Stahelin, 2001). In this context, the US Food and Nutrition Board has recently upwardly revised its recommendation for the daily dietary intake of phylloquinone, establishing an adequate intake of 90 and 120 µg/d, for adult females and males, respectively (Institute of Medicine, 2001), based on reported intakes in apparently healthy US population groups. There are limited data on dietary vitamin K₁ levels in European populations and, of those that are available, the use of different dietary tools precludes comparison in some cases. For example, mean intake estimates of vitamin K₁ in Scotland, UK and Norway of 60–80 µg/d were obtained using food records (Price *et al.* 1996; Askim, 2001; Thane *et al.* 2002), while estimates in The Netherlands (250 µg/d; Schurgers *et al.* 1999) were based on a food-frequency questionnaire.

There are currently no data on phylloquinone intakes or status in the Irish population. Therefore, the objective of the present study was to use the most recent Irish food consumption database (Irish Universities Nutrition Alliance, 2001), together with recent food composition data for vitamin K (Bolton-Smith *et al.* 2000a) to estimate the mean daily intake of phylloquinone, the adequacy of phylloquinone intakes and the contribution made by food groups to phylloquinone intakes in adults aged 18–64 years.

Methods

Survey sample and brief methodology

The food intake data used to estimate phylloquinone intakes in Irish adults were obtained from the North/South Ireland Food Consumption Survey (NSIFCS), a cross-sectional study that was carried out from 1997 to 1999 (Irish Universities Nutrition Alliance, 2001). Individuals aged 18–64 years were randomly selected using the electoral register as the sampling frame. Pregnant or lactating women were excluded. Analysis of the demographic features of the sample showed it to be representative of the Irish adult population at that time (Kiely *et al.* 2001). Food intake was estimated in 1379 respondents (662 males and 717 females) using a 7 d food record. Physical activity, lifestyle and socio-demographic variables were collected using self- or interviewer-administered questionnaires and anthropometric data including height, weight, waist and hip circumferences and body fat were measured.

Quantification of food and nutrient intake

The detailed methodology of the 7 d food diary, which was used to collect food and beverage intake data during the survey, and the methods used to quantify food and drink intake are described in detail by Harrington *et al.* (2001).

Food intake data were analysed using WISP[®] (Tinuviel Software, Warrington, UK), which uses data from *McCance and Widdowson's The Composition of Foods*, 5th ed. (Holland *et al.* 1995) and supplemental volumes to generate nutrient intake data (for more details, see www.tinuviel.u-net.com/wisp.htm). Modifications were made to the food composition database; 993 extra foods (including analysed recipes of composite dishes, nutritional supplements, generic Irish foods that were commonly consumed and new foods) were added. Harrington *et al.* (2001) have described the data handling and quality-control procedures that were used. The food consumption database generated from the survey listed each individual food item as consumed by each respondent, together with the nutrient composition for the quantity of each food consumed.

Phylloquinone content of foods

The WISP[®] software (because it relies on data from *McCance and Widdowson's The Composition of Foods*, 5th ed. (Holland *et al.* 1995) and supplemental volumes) does not include data on phylloquinone levels. A database established by Bolton-Smith *et al.* (2000a) contains the phylloquinone content of approximately 2000 foods and this database was applied to the food composition data provided by the NSIFCS. Direct analysis of the phylloquinone content in foods was carried out in the UK and the analytical methods used are described elsewhere (Bolton-Smith *et al.* 2000a). Of the 3060 different foods in the NSIFCS database, 1468 foods directly matched the UK database and were assigned phylloquinone values. Phylloquinone values were derived for the remaining 1592 foods by recipe calculation or based on similarity to other foods, as will now be described.

Recipe calculation. The research team working on the NSIFCS compiled a recipe file containing new recipes of typical foods consumed by the Irish population (for example, soda bread). Phylloquinone values for these recipes (*n* 545) were computed from the values of the basic ingredients obtained from the vitamin K database (Bolton-Smith *et al.* 2000a). Recipes (*n* 220) from *McCance and Widdowson's The Composition of Foods*, 5th ed. (Holland *et al.* 1995) and supplemental volumes were also designated phylloquinone values in the same way. In certain cases, if there was no phylloquinone value available for an ingredient in a recipe, the phylloquinone content of the recipe was calculated by substituting that ingredient with a value of a similar ingredient (for example, the value for plain white flour was substituted for potato flour in the recipe for potato bread). A number of manufactured foods (*n* 7) were given the phylloquinone value of a similar recipe food (for example, Green Isle savoury pancakes were designated the recipe value of homemade savoury pancakes). A collection of new recipes (*n* 52) was compiled from a website (RecipeSource, 2004) for manufactured foods for which a recipe had not previously been required (for example, chicken goulash, Rice Krispie squares).

Similarity to other foods. In foods where no phylloquinone data were available, values were calculated based on

their similarity to other foods, taking into account characteristics such as the fat content, the uptake of fat if fried and the edible proportion, using information provided by *McCance and Widdowson's The Composition of Foods*, 5th ed. (Holland *et al.* 1995). To attain compatibility between food codes in the food consumption and vitamin K composition databases, edible portions of sixty-one foods containing skin, bones, stones or shells (for example, fruit, nuts and fish) were calculated (Ministry of Agriculture, Fisheries and Food, 1997) and the vitamin K value of the edible portion on a w/w basis was used. The fat contents of foods (*n* 53) such as fish (for example, cod and mackerel) and biscuits were compared in order to estimate the vitamin K contents of these foods from generic codes (for example, white fish and oily fish). Values for some fried foods (*n* 31) were calculated using fat uptake data (for example, phylloquinone value of mushrooms fried in olive oil = phylloquinone value of raw mushrooms + quantity of phylloquinone in the amount of olive oil absorbed by the mushrooms during frying). In total, 296 phylloquinone values were assigned to foods based on their similarities to foods as described in the database of Bolton-Smith *et al.* (2000a).

Average phylloquinone values were inputted for 215 of the remaining foods. These mainly included meat and meat dishes, as there were approximately twice as many meats, meat products and meat dishes in the NSIFCS database (due to the high number of recipes) as the vitamin K database (Bolton-Smith *et al.* 2000a) and butchering practices in Ireland differ slightly from those in the UK. These meat codes were given the average phylloquinone value of the most similar meat codes (based on the descriptors), depending on the cut of meat (for example, for lean stewing lamb, an average value of five different cuts of lean lamb was assigned).

The remainder of the foods (*n* 103) could not be assigned any phylloquinone value. However, on investigation it was found that these were unusual foods and rarely consumed, so the absence of a value would not significantly affect the estimate of phylloquinone intake.

Compilation of the food groups. The major food groups contributing to the mean daily intake of phylloquinone are presented in Fig. 1. These seven food groups were derived from nineteen large food groups previously devised by the Irish Universities Nutrition Alliance (2001) based on the level of contribution the food group made to total phylloquinone intake. Two groups, alcohol and eggs, were excluded as they contributed <1% to the mean daily intake of phylloquinone. Bread and rolls, and biscuits, pastries and cakes were all aggregated into one food group. Milks and yoghurts, cream, ice cream and chilled desserts, cheeses and fat spreads were also aggregated to form a single food group. Seven Irish Universities Nutrition Alliance food groups that contributed <5% to the mean daily intake of total phylloquinone were aggregated to form the 'Other' group: grains, rice and savouries; breakfast cereals; fruit, juices, nuts, seeds, herbs and spices; fish and fish products; non-alcoholic beverages, sugar, confectionery, preserves and savoury snacks; nutritional supplements; sweeteners. The remaining four food groups were retained: vegetable group; potato group (including chipped and fried potatoes); meat group; soups, sauces and miscellaneous foods.

Assessment of adequacy of phylloquinone intake

As no average requirement has been established for vitamin K in adults it was not possible to use the cut-point method of Carriquiry (1999) to estimate the prevalence of inadequacy of dietary intake. However, the US Food and Nutrition Board has recently established an adequate intake of 90 and 120 µg/d for adult women and men, respectively (Institute of Medicine, 2001), based on reported intakes in apparently healthy US population groups. In the UK, the recommended intake for phylloquinone is 1 µg/kg body weight per d (Department of Health, 1991), based on its classical role in blood clotting. Therefore, to gain some measure of the adequacy of phylloquinone intakes, the proportions of the population not

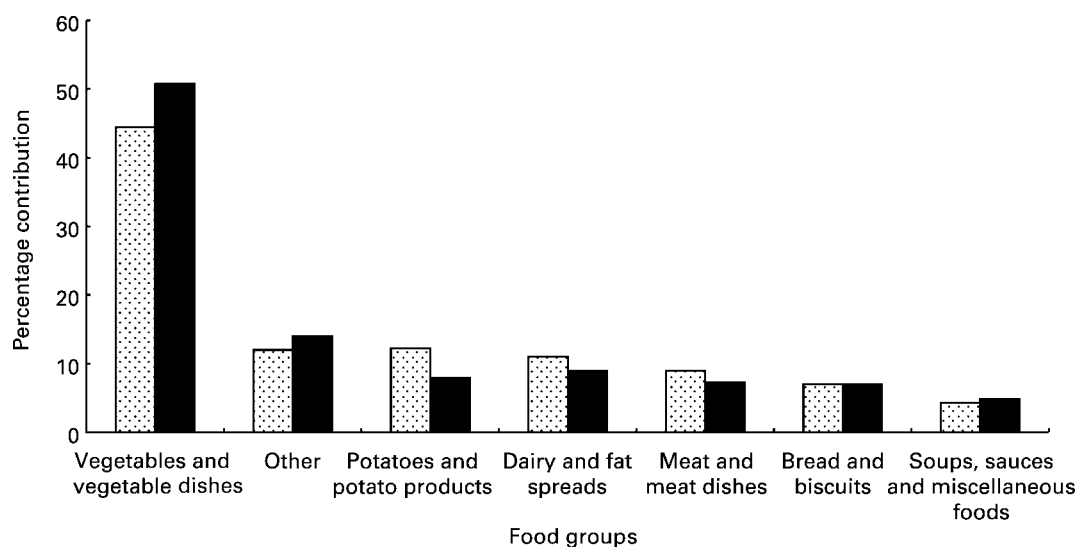


Fig. 1. Percentage contribution of main food groups to the mean daily intake of vitamin K₁ in men (▨) and women (■).

meeting the UK recommendation and consuming the US adequate intake were calculated.

Statistical analysis

Data manipulation and statistical analysis of the data were conducted using MS Excel[®] and SPSS[®] for Windows[™] version 10.0 (SPSS Inc., Chicago, IL, USA; Coakes & Steed, 1999). As the data were normally distributed, differences in phylloquinone intakes between men and women were compared using independent *t* tests, and differences between age groups were compared using one-way ANOVA using either Tamhane, if the Levene test for equality of variance was not satisfied, or Scheffé's *post hoc* test. Differences between educational levels, social class and smoking status within each sex were evaluated using a one-way analysis of covariance, adjusting intakes for age group, educational level, social class and smoking status (omitting one of the latter three, depending on which was the fixed factor).

Results

The mean daily intakes of phylloquinone (μg) from all sources (i.e. food and supplements), and from food sources only, in men and women of different ages are shown in Table 1. The mean daily intake of phylloquinone in the total group from all sources was 80 (SD 44) μg and from food sources only was 79 (SD 44) μg , showing that about 99% of the phylloquinone intake came from food. Intakes of phylloquinone (from all sources) were significantly higher ($P < 0.001$) in men (84 $\mu\text{g}/\text{d}$) than in women (75 $\mu\text{g}/\text{d}$). However, energy-adjusted intakes (expressed as $\mu\text{g}/10\text{MJ}$ food energy) were significantly higher ($P < 0.001$) in women than in men of all ages (105 and 83, respectively). In both men and women, phylloquinone intakes were significantly lower ($P < 0.01$) in the 18–35-year age group than in the 36–50-year age group, with no differences between 36–50-year-olds and 51–64-year-olds. In women, but not men, the phylloquinone intake of the 18–35-year age group was also significantly lower ($P < 0.01$) than the 51–64-year age group.

The mean daily intakes of phylloquinone from all sources, in men and women of different socio-demographic backgrounds, are shown in Table 2. These mean intake values are adjusted for age group, educational level, social class and smoking status. Phylloquinone intakes did not vary significantly with educational level in either men or women. With regard to social class and smoking status, there were significant differences seen in men. The phylloquinone intake of professional men was significantly higher ($P < 0.05$) than men with a non-manually skilled background. The mean daily phylloquinone intake of male smokers was significantly lower ($P < 0.05$) than non-smokers.

The mean daily intakes of phylloquinone (percentage of total intake) from the main food groups in men and women are presented in Fig. 1. Overall, vegetables and vegetable dishes contributed 48% of the total phylloquinone intake. Potatoes and potato products (primarily from the oils used in chips and fried potatoes) and dairy and fat spreads each

contributed 10%, and meat and meat products also made a significant contribution of 8%. Fig. 2 shows the vegetables that provided most of the mean daily intake of phylloquinone. Of the green vegetables, which collectively contributed 26% to the total phylloquinone intake, cabbage was the best single provider of phylloquinone, providing 11% of total intake, followed by broccoli (7%) and lettuce (4%).

Of the 1379 participants in the study, which was a representative sample of the Irish adult population, 52% had phylloquinone intakes below the UK recommendation of 1 $\mu\text{g}/\text{kg}$ body weight per d (Department of Health, 1991), while 28% (31% of men, 24% of women) failed to meet 70% of this recommendation. Furthermore, when phylloquinone intake data were compared with current US adequate intakes (Institute of Medicine, 2001), only 17% of men and 27% of women met these intakes of 120 and 90 $\mu\text{g}/\text{d}$, respectively.

Discussion

In the present study, the assigned phylloquinone content values of some foods are provisional (Bolton-Smith *et al.* 2000a). This is because phylloquinone contents vary according to the part of the food consumed, the types of oils used in food production and preparation and their degree of hydrogenation, as well as soil and growth conditions, geographical location, seasonal variation and maturity, and by heating and UV light exposure (Ferland & Sadowski, 1992; Thane *et al.* 2002). Notwithstanding these inherent limitations in our food composition data, the present study is the first to estimate the phylloquinone intake of an Irish population and one of the few to present data in a representative population sample. Phylloquinone intakes and main dietary sources in the present study are comparable with those reported for studies in the UK (Price *et al.* 1996; Fenton *et al.* 1997; Thane *et al.* 2002). The mean phylloquinone intakes reported in the present study of 84 and 75 $\mu\text{g}/\text{d}$ in men and women, respectively (80 $\mu\text{g}/\text{d}$ for the entire group, aged 18–64 years) were only marginally higher than the values of 76 and 69 $\mu\text{g}/\text{d}$ reported for Scottish men and women, respectively (73 $\mu\text{g}/\text{d}$ for entire group, aged 25–65 years) (Price *et al.* 1996). In 1995, a 10-year follow-up study of the Scottish Heart Health Study participants estimated phylloquinone intakes of 54 $\mu\text{g}/\text{d}$ for men and 56 $\mu\text{g}/\text{d}$ for women (Bolton-Smith *et al.* 2000b). In elderly men and women, Thane *et al.* (2002) recently reported mean phylloquinone intakes of 84 and 73 $\mu\text{g}/\text{d}$ (about 78 $\mu\text{g}/\text{d}$ for entire group) in the UK. Reported phylloquinone intakes of other European populations are limited and, in some cases, have used different dietary tools that preclude comparison with the present data. For example, in The Netherlands, Schurgers *et al.* (1999) reported mean daily phylloquinone intakes of 250 $\mu\text{g}/\text{d}$; however, these intake data were obtained using a food-frequency questionnaire. As the food-frequency questionnaire can tend to estimate higher vegetable intakes than a food diary method, phylloquinone estimates from these two assessment tools should not be compared.

Mean phylloquinone intakes were reported for a nationally representative sample of US consumers (n 3967), aged

Table 1. Daily intakes of vitamin K₁ (µg) in Irish adults, from all sources (food and supplements) and from food sources only† (Mean values and standard deviations, and median values and 5th and 95th percentiles)

	All						Men						Women														
	18–35 years		36–50 years		51–64 years		All ages		18–35 years		36–50 years		51–64 years		All ages		18–35 years		36–50 years		51–64 years						
	(n 1379)	(n 522)	(n 522)	(n 522)	(n 335)	(n 662)	(n 253)	(n 236)	(n 173)	(n 717)	(n 269)	(n 286)	(n 162)	(n 1379)	(n 522)	(n 522)	(n 335)	(n 662)	(n 253)	(n 236)	(n 173)	(n 717)	(n 269)	(n 286)	(n 162)		
All sources																											
Mean	79.5	72.6 ^A	83.3 ^B	84.3 ^B	84.3 ^B	84.2	77.6 ^A	89.3 ^b	86.8 ^{ab}	75.2 ^{**}	67.9 ^{8*}	78.3 ^{b*}	81.7 ^b	79.5	72.6 ^A	83.3 ^B	84.3 ^B	84.2	77.6 ^A	89.3 ^b	86.8 ^{ab}	75.2 ^{**}	67.9 ^{8*}	78.3 ^{b*}	81.7 ^b		
SD	44.2	37.6	40.3	40.3	56.5	48.7	38.9	43.5	64.8	39.1	35.7	36.8	46.2	44.2	37.6	40.3	56.5	48.7	38.9	43.5	64.8	39.1	35.7	36.8	46.2		
Median	70.9	66.4	75.5	74.5	74.5	73.7	69.6	80.5	74.4	68.6	61.3	73.9	75.0	70.9	66.4	75.5	74.5	73.7	69.6	80.5	74.4	68.6	61.3	73.9	75.0		
Percentiles																											
5th	28.5	26.7	32.1	32.1	27.0	30.0	28.8	31.5	31.5	27.9	23.8	32.6	24.8	28.5	26.7	32.1	32.1	30.0	28.8	31.5	31.5	27.9	23.8	32.6	24.8		
95th	157.2	137.9	160.4	160.4	162.5	162.2	155.6	168.2	168.2	146.0	130.0	152.6	161.5	157.2	137.9	160.4	162.5	162.2	155.6	168.2	168.2	146.0	130.0	152.6	161.5		
Food sources																											
Mean	78.7	71.6 ^A	82.8 ^B	82.8 ^B	83.5 ^B	83.7	77.2 ^a	88.8 ^b	86.2 ^{ab}	74.1 ^{**}	66.4 ^{8*}	77.8 ^{b*}	80.7 ^b	78.7	71.6 ^A	82.8 ^B	83.5 ^B	83.7	77.2 ^a	88.8 ^b	86.2 ^{ab}	74.1 ^{**}	66.4 ^{8*}	77.8 ^{b*}	80.7 ^b		
SD	44.1	37.4	40.2	40.2	56.4	48.6	38.7	43.3	64.8	39.0	35.5	36.8	45.8	44.1	37.4	40.2	56.4	48.6	38.7	43.3	64.8	39.0	35.5	36.8	45.8		
Median	70.1	65.6	75.4	75.4	73.3	72.6	69.5	80.0	73.2	67.1	60.0	72.4	74.2	70.1	65.6	75.4	73.3	72.6	69.5	80.0	73.2	67.1	60.0	72.4	74.2		
Percentiles																											
5th	28.3	26.1	31.8	31.8	27.0	30.0	28.8	31.0	28.1	27.5	23.3	32.1	24.8	28.3	26.1	31.8	27.0	30.0	28.8	31.0	28.1	27.5	23.3	32.1	24.8		
95th	155.9	137.6	159.2	159.2	162.1	162.1	155.2	165.5	165.3	145.9	130.0	148.0	151.6	155.9	137.6	159.2	162.1	162.1	155.2	165.5	165.3	145.9	130.0	148.0	151.6		

^{A, B}Mean values within a row with unlike superscript letters were significantly different ($P < 0.01$).

^{a, b}Mean values within a row, in each sex group separately, were significantly different ($P < 0.01$).

Mean vitamin K₁ intake was significantly different to that of the corresponding age group in men: * $P < 0.01$, ** $P < 0.001$.

† For details of subjects and procedures, see p. 150.

Table 2. Daily intakes of vitamin K₁ (μg) in Irish men and women, by selected socio-demographic and lifestyle factors* (Mean values and standard deviations)

	Men			Women		
	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD
Educational level						
Primary	135	83	55	135	72	40
Intermediate	126	83	41	149	73	39
Secondary	102	83	41	132	80	31
Third level	253	86	52	247	78	44
Social class						
Managerial, professional and technical	265	90 ^a	54	297	82	44
Non-manual skilled	90	77 ^b	37	160	72	36
Manual skilled	151	85 ^{ab}	51	105	73	33
Semi-skilled and unskilled	110	77 ^{ab}	40	101	67	33
Smoking status						
Smoker	202	77 ^a	38	213	70	33
Ex-smoker	165	88 ^{ab}	57	145	78	38
Non-smoker	249	88 ^b	50	305	79	43

^{a,b}Mean values within a column, within a socio-demographic or lifestyle factor, with unlike superscript letters were significantly different ($P < 0.05$).

* For details of subjects and procedures, see p. 152.

13+ years, at levels of 81 and 73 $\mu\text{g}/\text{d}$ in men and women, respectively (about 76 $\mu\text{g}/\text{d}$ for entire group) (Booth *et al.* 1999). Although the mean daily phylloquinone intakes of the present study are similar to reported US and European intakes, there is evidence to suggest that these levels may be insufficient for the maintenance of bone health. In the Nurses' Health Study, phylloquinone intakes less than 109 $\mu\text{g}/\text{d}$ were associated with an increased risk of hip fracture (Feskanich *et al.* 1999). In the Framingham Heart Study, elderly men and women in the highest quartile of phylloquinone intake (median 254 $\mu\text{g}/\text{d}$) had a significantly lower adjusted relative risk of hip fracture than did those in the lowest quartile of intake (median 56 $\mu\text{g}/$

d) (Booth *et al.* 2000). Furthermore, low dietary phylloquinone intakes have recently been associated with low bone mineral density (Booth *et al.* 2003). Women in the lowest quartile of vitamin K intake (70 $\mu\text{g}/\text{d}$) had significantly lower ($P < 0.005$) mean bone mineral density at the femoral neck and spine than did those in the highest quartile of vitamin K intake (309 $\mu\text{g}/\text{d}$) (Booth *et al.* 2003).

Some studies have reported a decrease in phylloquinone intake with age, but especially in adults over the age of 65 years and, more notably, over the age of 85 years (Schurgers *et al.* 1999; Thane *et al.* 2002). In the present study, there was no decrease in phylloquinone intakes with age up to 64 years. In fact, younger adults (aged 18–35

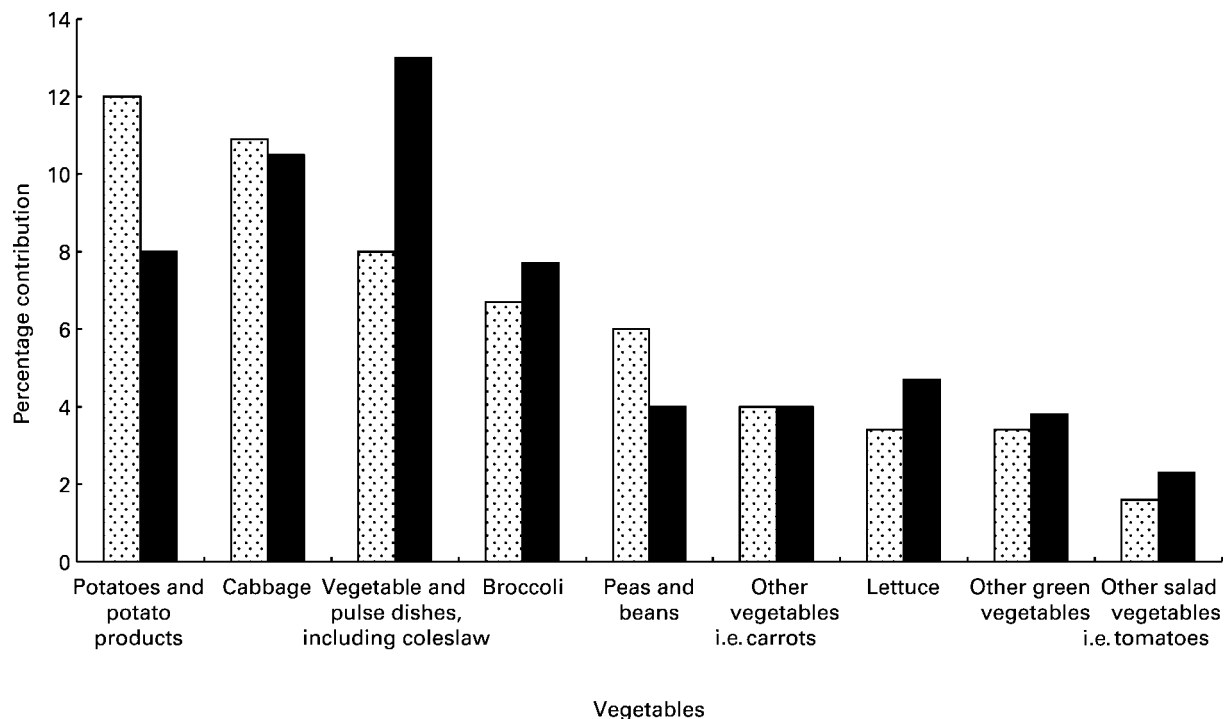


Fig. 2. Percentage contribution of different vegetable groupings to the mean daily intake of vitamin K₁ in men (▨) and women (■).

years) had a lower mean phylloquinone intake than older adults (aged 36–64 years), which is probably due to the lower vegetable consumption of younger Irish adults compared with over-35-year-olds, previously reported by O'Brien *et al.* (2003). Booth & Suttie (1998) reviewed eleven vitamin K intake studies in different population groups and found that studies showed consistently higher intakes in older adults than younger adults, most probably due to lower green vegetable consumption in younger adults.

Phylloquinone is ubiquitously distributed in the diet; however, the range of concentrations in different food groups is very wide (Shearer *et al.* 1996). In the present study, 35% of the 3060 foods recorded as consumed in the NSIFCS contained less than 1 µg phylloquinone/100 g food. In addition, 80% of foods had less than 10 µg phylloquinone/100 g, and 95% contained less than 100 µg/100 g. The highest concentrations of phylloquinone (400–3000 µg/100 g) were found in green vegetables, such as parsley, spinach and cabbage. Intermediate amounts (100–200 µg/100 g) were found in broccoli, lettuce, coleslaw and vegetable oils. Potatoes and meat contain relatively little phylloquinone (µg/100 g), but in the present study, the meat group and potato group (including chipped and fried potatoes) contributed significantly to mean daily intakes of phylloquinone (about 18%) due to the considerable quantities consumed and to the contribution from vegetables consumed in meat dishes.

As vegetables and vegetable dishes were the main dietary sources of phylloquinone, this food group was examined in more detail so as to identify the important sources of phylloquinone in the Irish diet. Green vegetables alone (including lettuce) contributed 26% to the total intake, a value similar to the 28% reported for these foods in Scotland (Fenton *et al.* 1997). Of the green vegetables, cabbage was the best single provider of phylloquinone, providing 11% to total intake, followed by broccoli (7%) and lettuce (4%).

Phylloquinone intakes were also examined in the population stratified by indicators of socio-economic status, namely, educational level and social class. Intakes in smokers and non-smokers were also compared. Higher phylloquinone intakes were found in professionals than any other social class (as defined by occupation), particularly in men. This could be attributable to the differences in vegetable consumption between socio-economic groups, which have been observed in this population (O'Brien *et al.* 2003). Male smokers had lower intakes than non-smokers but educational differences were not observed in men or women.

In summary, similar to findings in Scottish adults (Price *et al.* 1996) and British elderly (Thane *et al.* 2002), habitual intakes of phylloquinone in Irish adults may not be adequate to maintain bone health, on the basis of comparisons with both the 1991 UK recommendations and the 2001 US adequate intakes for phylloquinone. Younger adults appear to be at a higher risk of inadequacy due to lower than average intakes of green vegetables. Strategies to increase phylloquinone intakes include increasing consumption levels of green vegetables, and/or food fortification. Investigations of phylloquinone intakes in other age

groups, particularly the elderly and young children, are warranted, as are investigations of vitamin K status in at-risk population groups.

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