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Association between legume consumption and the intake of other foods and nutrients in the Finnish adult population

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Abstract

The role of legumes in healthy and sustainable diets is increasingly of interest. Few studies have investigated the association between legume consumption and the consumption of other food groups and the intake of nutrients. This study examined how legume consumption is associated with the consumption of other foods and the intake of nutrients among Finnish adults. Our study used cross-sectional data from the population-based FinHealth 2017 Study consisting of 2250 men and 2875 women aged ≥18 years. The associations between legume consumption (quartile classification), food groups and nutrients were analysed using multivariable linear regression. The models were initially adjusted for energy intake and additionally for age, educational level, smoking status, leisure-time physical activity and BMI. Legume consumption had a positive association with age, education level and leisure-time physical activity. The consumption of legumes was positively associated with the consumption of fruits and berries, vegetables, nuts and seeds and fish and fish products and inversely associated with the consumption of red and processed meat, cereals and butter and butter-based fat spreads. Furthermore, legume consumption was positively associated with the intake of protein, fibre, folate, thiamine and salt in both sexes and inversely associated with the intake of saturated fatty acids and sucrose (sucrose, women only). Thus, legume consumption appears to reflect overall healthier food choices. An increase in legume consumption could accelerate the transition to more sustainable diets. The confounding role of other foods and nutrients should be considered when studying associations between legume consumption and health outcomes.

Key words: Food consumption: Legumes: Nutrients: Socio-demographic factors: Sustainability: Diet

The increasing effort to mitigate the environmental and nutritional challenges posed by the current food systems in Western countries has highlighted the need for individuals to adopt more plant-based diets[1]. Legumes are of particular value in plant-based diets. Leguminosae or Fabaceae commonly known as legumes or pea family are crop plants with edible seeds that have been used for many years for human and animal consumption. Legumes include crops that are produced for fresh consumption as vegetables (green peas and green beans), some as dry grains (pulses: e.g. dry peas, beans and lentils), some for oil extracting purposes (soybean) and some for sowing purposes (alfalfa and clover)[2].

Legume consumption varies worldwide. Although its consumption has declined all around the world[3], they are still highly consumed in some areas such as South Asia, the Middle East and the Mediterranean area[4]. Whereas, in Western Europe, their consumption remains low[5]. In the Nordic countries, including Finland, legume consumption is especially low[6,7] compared with the Eat Lancet Commission's reference diet (75 g/d), so called planetary health diet, which refers to both human health and environmental sustainability[8]. According to the latest national food consumption survey in Finland, FinDiet 2017, the mean consumption for legumes among women is only 13 g/d and among men 12 g/d, with cooked green peas (mainly in pea soup) being the most common leguminous food eaten (45 % share), followed by green beans, kidney beans and soya mince (each 10 %)[9,10]. Legumes are a valuable source of complex carbohydrates and slowly digestible starch such as oligosaccharides and phenolic compounds as well as fibre[11,12] and are rich in nutrients such as riboflavin, thiamine and especially folate[13]. Therefore, regular legume consumption may reduce the risk of CVD and risk factors such as blood pressure, inflammation and lipid profiles as well as the risk of colorectal cancer[14–16].

Although considerable research has been devoted to the association between legume consumption and health outcomes, only a limited number of international studies have investigated legume consumption in relation to the consumption of other foods and intake of nutrients[7,17–19]. Such studies would be of importance when planning epidemiological research around legumes and interpreting their results. Moreover, characterising diets of individuals with high legume consumption can play an important role in the identification of healthy diets already

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adopted in the population and thereby increasing public health knowledge of legume consumption and improving recommendations.

Two studies from the US using the National Health and Nutrition Examination data reported that, compared with non-consumers, consumers with the highest legume consumption had a higher intake of main legume-derived nutrients such as folate, Fe and Mg, as well as carbohydrates and a lower intake of total fat[18,20]. A Canadian study[17] using the 2004 Canadian Community Health Survey observed a positive association between legume consumption and energy, folate and Zn intake as well as the consumption of fruits and vegetables. Additionally, they found an inverse association for cholesterol intake for the highest legume consumers compared with non-consumers, whereas no association was observed with fats. These three studies mainly included pulses (dry legume grains). In the Swedish population, a positive association was observed between high consumption of legumes (compared with non-consumers) and the intake of energy, fibre, folate, Mg, potassium and Fe, using the national Riksmaten Survey data[7]. Additionally, using the principal component analysis, they observed an association between high consumption of legumes and healthier food choices (such as fruits, nuts, seeds and tea) among women. They included pulses, fresh legumes, peanuts, soya products, sprouts and mixed meals with legumes in their study.

This study, for the first time in Finland and second in Europe (first study conducted in Sweden[7]), aims to investigate how legume consumption is associated with the consumption of other foods and intake of nutrients in adult men and women to strengthen the knowledge on the role of legumes in prevailing diets/dietary patterns in Nordic countries and Europe. Primarily, the findings of this study have implications for nutritional research, studying the associations between legume consumption and health outcomes. Further implications are for Finland and other countries to better characterise legume consumers.

Methods

Study population

FinHealth 2017 is a nationally representative study that gathered information on the health and well-being of the adult population in Finland[21,22]. The FinHealth 2017 Study was conducted between January and May 2017 and comprised a thorough health examination and several health questionnaires including a FFQ. An invitation letter to a health examination along with the first health questionnaire was sent to the eligible sample obtained from the Finnish population register (n 10 247, age range 18 years and over). Of the eligible participants, 58 % participated in the health examination (n 5952). Of those who participated in the health examination, 89 % returned the FFQ.

After the exclusion of incomplete and incorrectly filled FFQ (n 119), those who withdrew written consent (n 7) and those outside the daily energy intake cut-off points (0·5 % of participants at both ends of the sex-specific daily energy intake distributions) (n 51), the final population for this study comprised 5125 participants (2875 women and 2250 men)[22,23].

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and the ethical guidelines of the Finnish Institute for Health and Welfare and Tampere University. All procedures involving human subjects were approved by the Ethics Committee of the Hospital District of Helsinki and Uusimaa (Reference 37/13/03/00/2016). Written informed consent was obtained from all subjects[24].

Dietary data

All food group and nutrient data for this study were derived from a semi-quantitative FFQ enquiring about the participants' habitual food consumption over the past 12 months. The reproducibility and validity of the FFQ, referring to the general adult population in Finland, has been documented and found to be reliable and valid for epidemiological studies[25–27]. The FFQ consists of 134 items on foods, mixed dishes and beverages generally consumed in Finland. The frequency of consumption was categorised into ten groups, ranging from never to at least 6 times a day. The sex-specific portion sizes were specified by natural units (for example, serving, slice, glass and cup) or weight/volume measures[22]. Daily consumption of foods (ingredient level, g/d) and nutrient intakes (g/d) were calculated using the National Food Composition Database (FINELI®) and the FINESSI software of THL[28].

The main exposure variable, legumes, was composed of three main categories: peas and beans, soya products and legume-based meat alternatives. The first category includes green and dry peas, beans and lentils, either frozen or cooked and prepared, including canned products. The soya products include tofu, crushed soya and other soya-based products. Legume-based meat alternatives refer to those products in which non-soya legumes are the main ingredients, such as fava bean-based meat alternative product. Of these three categories, the first two were the most important at the time of FinHealth 2017, since there are traditional dishes with peas still in common use in Finland, and vegan/vegetarians have used peas, beans and soya for a long time. Whereas, the plant protein products had just entered the market[29]. Peanuts were included in nuts and seeds (not in legumes) due to their usual mode of consumption in the Finnish diet.

Food groups were chosen to characterise best the Finnish diet. Some of the food group variables in the same category were merged, to ease the analysis process and interpretation of results. For instance, among cereals, rye, oat and barley were merged and regarded as the healthy option, as they are the main whole grain sources in the Finnish diet, and wheat and rice as the less healthy option. In Finland, wheat is mostly consumed as refined, in the form of white wheat bread, pastries and sweets. Rice consumption is quite low, and polished rice is the most commonly consumed type[9]. Additionally, for milk products, products such as milk and yoghurt were categorised into liquid milk products. Cheese was categorised separately. This was done to examine whether there was, in general, a different pattern with regard to liquid milk products or cheeses in relation to legume consumption. Moreover, all vegetable-based fat spreads, such as margarine and oil (vegetable-based oil) regarded as healthy options, were merged as vegetable-based fat spreads and oil.

Whereas, butter and other butter–oil mixtures, regarded as unhealthy options, were categorised as butter and butter-based fat spreads. The nutrients for the analysis were chosen based on the nutrient content of legumes, the nutrient intake status of the Finnish population and previous studies[7,9,17,18,20].

Socio-demographic and lifestyle factors and anthropometric measures

The socio-demographic and lifestyle data utilised in this study were obtained primarily from self-administered questionnaires[30]. Other background data such as age and sex (for the FinHealth 2017 study) were obtained from the sampling frame (national population register)[31]. Total years of education were categorised into tertiles (low, middle and high), taking into account the participants' sex and birth year. This was done to adjust for the increase in school years and changes in the Finnish educational system during the past decades. Leisure time physical activity was initially assessed based on four categories: inactive (activities that are not physically straining like reading and watching TV), moderately active (activities like walking, light home gardening, fishing and cycling several h/week), active (activities such as running, swimming, fitness training, cross-county skiing and strenuous gardening several hours a week) and highly active (including competitive sports regularly and several times/week like running, cross-country skiing and ball games). The last two categories were merged because of the low number of participants in the highly active category. Smoking was initially categorised into four groups: non-smokers (never smoked or did not smoke regularly), quit ≥6 months ago, quit <6 months ago and current smoker. Because of the low number of participants who quit ≥6 months ago and quit <6 months ago, these categories were combined and renamed as 'former smokers'.

Height (cm) and weight (kg) of the participants were measured during the health examinations by specially trained nurses, according to international standard protocols[32]; height was measured to the closest 0·1 cm measure and weight was measured with participants wearing light clothes and no shoes to the closest 0·1 kg[33]. Body mass index (BMI) was calculated as weight (kg) divided by the squared height (m^2).

Statistical analyses

Almost all participants consumed at least some legumes in the past year, since legumes are contained in some of the dishes included in the FFQ. There were only two participants who did not consume any legumes. Therefore, a separate non-consumer group was not included in this study. However, the two non-consumers were included in the lowest quartile of legume consumption. There are significant differences in dietary patterns in general, as well as legume consumption between women and men in Finland[9,34]. Hence, analyses were conducted separately for women (n 2875) and men (n 2250). The participants (n 5125) were classified by sex, into quartiles (Q) of legume consumption (Q1–Q4).

Socio-demographic and lifestyle characteristics, including age, educational level, smoking status, leisure time physical activity level and BMI, were first compared across legume quartiles. Age and BMI were used as continuous variables. Median and interquartile range were calculated for quantitative variables and percentages for categorical variables. The P value of the associations was calculated using Kruskal–Wallis test for continuous variables and the χ^2 test for categorical variables.

Since the distribution of the food level outcome variables and nutrients were positively skewed, $\log_{10}$ transformation was chosen based on the shape of residuals' distributions. To conduct logarithmic transformation and geometric means, "1" was added to all the values of those variables that had a value zero. To obtain the energy-adjusted geometric means of each food group and nutrient outcome (since the outcome variables were log transformed) for each quartile, legume quartiles were used as a categorical variable and each outcome and energy (kJ/d), as a continuous variable in the analysis of covariance.

To determine the association between legume consumption and other food groups and nutrients, multivariable linear regression was firstly used for all the variables. All food groups and nutrients were adjusted for energy intake by including energy intake in the models. This was done to focus on diet quality rather than absolute intake, thereby removing confounding by energy intake. We constructed two statistical models. The energy-adjusted model was constructed using each food group or nutrient at a time as the dependent variable and the medians of legume quartiles and energy intake (kJ/d), as independent continuous variables. The multivariable model was constructed using each food group or nutrient at a time as the dependent variable and the medians of legume quartiles, energy intake (kJ/d), age and BMI as independent continuous variables and educational level, smoking status and leisure-time physical activity as independent categorical variables.

For variables nuts and seeds, rye, oat and barley, liquid milk products, butter and butter-based fat spreads, fish and fish products, poultry and alcohol, the distributions of residuals of linear regression models were not fully normalised after transformation. Therefore, for these variables, the results were checked using multinomial logistic regression. Multinomial models were created by categorising these variables into ten ordered groups, each including approximately 10 % of cases. After that, both energy-adjusted and multivariable models were created using the categorised variable as dependent variable. All analyses were performed using the IBM SPSS statistical software, version 26.

Results

In this study, 56 % of the participants were women. The unadjusted median legume consumption was low in both women (8·9 g/d, interquartile range 5·1–15·7) and men (9·6 g/d, interquartile range 5·8–15·7). However, there was a substantial variation in legume consumption: the median of the highest quartile was nearly eight times higher than that of the lowest quartile for both sexes. The medians for the Q1–Q4 were 3·0, 6·8, 11·3 and 26·0 g/d for women and 3·3, 7·5, 12·2 and 25·8 g/d for men, respectively. High legume consumption was positively associated with younger age, higher educational level and higher leisure-time physical activity level. Legume consumption was not

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Table 1. The socio-demographic and lifestyle characteristics of the participants (women (*n* 2875) and men (*n* 2250)) by the quartiles of total legume consumption (median (interquartile range (IQR) or numbers (percentage %))

	Q1* median/*n*	IQR/%	Q2 median/*n*	IQR/%	Q3 median/*n*	IQR/%	Q4 median/*n*	IQR/%	*P*-value†
Age									
Women	60·0	26·0	57·0	26·0	57·0	26·0	55·0	27·0	0·001
Men	58·0	23·0	59·0	23·0	59·0	24·0	55·0	26·0	0·004
Educational level‡									
Women									<0·001
Low	252	35·5	238	33·8	224	31·8	175	25	
Middle	256	36·1	244	34·6	239	33·9	236	33·7	
High	202	28·5	223	31·6	241	34·2	289	41·3	
Men									<0·001
Low	202	36·2	187	33·9	172	31·1	139	25	
Middle	180	32·3	177	32·1	174	31·5	176	31·6	
High	176	31·5	188	34·1	207	37·4	242	43·4	
Smoking status									
Women									0·10
Non-smokers	457	64·2	457	64·5	481	67·7	484	68·3	
Former smokers	146	20·5	168	23·7	143	20·1	149	21·0	
Current smokers	109	15·3	84	11·8	87	12·2	76	10·7	
Men									0·08
Non-smokers	274	49·1	257	46·2	273	49·1	310	55·9	
Former smokers	192	34·4	199	35·8	187	33·6	164	29·5	
Current smokers	92	16·5	100	18·0	96	17·3	81	14·6	
Physical activity level§									
Women									0·001
Inactive	231	32·5	179	25·2	173	24·3	162	22·9	
Moderately active	318	44·7	351	49·4	343	48·2	343	48·6	
Highly active	162	22·8	181	25·5	195	27·4	201	28·5	
Men									<0·001
Inactive	160	28·5	129	23·2	112	20·0	96	17·2	
Moderately active	241	43·0	250	45·0	267	47·7	257	46·0	
Highly active	160	28·5	177	31·8	181	32·1	206	36·9	
BMI (kg/m²)									
Women	26·2	6·5	26·6	7·1	26·9	6·1	26·0	6·8	0·06
Men	27·1	6·0	27·3	5·3	26·7	5·5	26·8	5·5	0·14

Q, quartile.
* Crude legume consumption range in each quartile (g/d) for women is: ≤5·09, 5·10–8·88, 8·89–15·66 and ≥15·67 and for men: Q1 (≤5·76), Q2 (5·77–9·61), Q3 (9·62–15·70) and Q4 (≥15·71).
† The *P* value of the associations was calculated using Kruskal–Wallis test for continuous variables and χ^2 test for categorical variables. *P* values are significant at 0·050.
‡ Educational level was obtained by categorising total years of education into tertiles, considering the sex and birth year.
§ Only leisure time physical activity was included.

statistically significantly associated with smoking and BMI (Table 1).

There was a positive association between legume consumption and several food groups, such as fruits and berries, vegetables, nuts and seeds and vegetable-based fat spreads and oil (Table 2). For instance, the difference between the mean consumption of vegetables in the highest and lowest quartile for women was 151 g/d. Among men in the highest legume consumption quartile, the mean consumption of vegetables, 274 g/d, was twice that of the lowest quartile, 137 g/d. The highest quartile of legume consumers had the lowest intake of cereals. Additionally, there was a negative association between legume consumption and red and processed meat and butter and butter-based fat spreads in both sexes. For instance, for red and processed meat, the difference in the mean consumption in the lowest and highest quartiles was 17 g/d for women and 6 g/d for men.

Legume consumption was positively associated with cheese in the energy-adjusted model, but this association attenuated (to non-significant) in the multivariable model. Additionally, the inverse association for rye, oat and barely was significant in the energy-adjusted model only. There was a negative association between legume consumption and potato among women. Among men, this association was positive and became significant in the multivariable model. Furthermore, the inverse association for chocolate and sweets in men became significant in the multivariable model (among women significant in both models).

The results of the multinomial models were essentially similar to the results of the linear regression models. For some variables, the statistical significance of the *P* values changed. For females, this occurred for variable rye, oat and barley in the multivariable model. For males, changes were in the following variables: rye, oat and barley (multivariable model), liquid milk products (energy-adjusted and multivariable model), butter and butter-based fat spreads (energy-adjusted model and multivariable model) and poultry (energy-adjusted model).

The associations between legume consumption and the intake of nutrients are presented in Table 3. The associations were statistically significant for most of the studied nutrients in both sexes. Legume consumption was positively associated with the intake of protein, PUFA, fibre, vitamins A, E and C, folate,

Table 2. Food consumption (g/d) by legume consumption quartiles (g/d) for women (*n* 2875) and men (*n* 2250) (energy-adjusted geometric means and their 95 % confidence intervals (CI))

	Q1		Q2		Q3		Q4		*P*-value† energy-adjusted model	P-value‡ multivariable model
Legume quartiles (g/d)	Quartile median*	Range	Quartile median*	Range	Quartile median*	Range	Quartile median*	Range		
Women	3·04	≤5·09	6·78	5·10–8·88	11·33	8·89–15·66	25·99	≥15·67		
Men	3·31	≤5·76	7·51	5·77–9·61	12·18	9·62–15·70	25·80	≥15·71		
	Mean§	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI		
Fruits and berries										
Women	116	110, 123	139	131, 148	157	148, 166	165	156, 175	<0·001	<0·001
Men	81	75, 87	98	91, 106	107	99, 116	122	113, 132	<0·001	<0·001
Vegetables										
Women	172	165, 179	217	208, 226	257	247, 268	323	310, 338	<0·001	<0·001
Men	137	130, 144	172	163, 181	205	194, 216	274	259, 289	<0·001	<0·001
Nuts and seeds‖										
Women	3·5	3·3, 3·8	4·2	3·9, 4·6	4·9	4·5, 5·2	6·2	5·8, 6·7	<0·001	<0·001
Men	2·8	2·6, 3·1	3·2	3·0, 3·5	3·6	3·3, 3·9	4·5	4·3, 4·9	<0·001	<0·001
Potato‖										
Women	58	55, 61	63	60, 66	63	60, 66	53	50, 56	<0·001	0·016
Men	88	83, 93	98	93, 104	99	93, 104	94	89, 100	0·41	0·029
Cereals										
Women	94	91, 97	94	91, 97	92	89, 95	85	82, 88	<0·001	<0·001
Men	112	108, 116	114	110, 119	114	110, 118	101	97, 105	<0·001	<0·001
Wheat and rice										
Women	51	49, 52	52	51, 54	53	51, 54	49	48, 51	0·07	0·08
Men	64	62, 66	68	65, 70	66	64, 69	63	61, 66	0·16	0·07
Rye, oat and barley‖										
Women	45	43, 48	47	44, 50	44	41, 46	41	39, 44	0·007	0·13
Men	47	44, 50	50	46, 53	53	50, 57	44	41, 47	0·040	0·24
Liquid milk products										
Women	343	324, 365	346	327, 367	326	308, 346	292	275, 310	<0·001	<0·001
Men	358	333, 386	361	336, 389	375	349, 404	338	314, 365	0·20	0·13
Cheese‖										
Women	32	30, 34	35	33, 37	36	34, 38	36	34, 38	0·049	0·09
Men	36	33, 39	37	35, 40	39	37, 42	40	37, 43	0·044	0·31
Vegetable-based fat spreads and oil										
Women	12·2	11·5, 13·0	13·91	13·1, 14·7	14·2	13·4, 15·1	15·2	14·3, 16·1	<0·001	<0·001
Men	14·5	13·6, 15·5	15·2	14·2, 16·2	16·2	15·2, 17·3	16·6	15·6, 17·7	0·004	0·047
Butter and butter-based fat spreads										
Women	8·1	7·5, 8·7	8·1	7·6, 8·7	8·4	7·8, 9·0	6·5	6·1, 7·0	<0·001	<0·001
Men	9·1	8·4, 9·8	9·7	9·0, 10·5	9·3	8·6, 10·0	8·2	7·6, 8·9	0·014	0·047
Fish and fish products‖										
Women	28	26, 29	33	31, 35	37	35, 40	35	33, 37	<0·001	<0·001
Men	34	32, 37	41	38, 44	46	44, 50	51	47, 54	<0·001	<0·001
Poultry										
Women	23	21, 25	26	24, 29	26	24, 28	21	19, 22	0·002	<0·001
Men	25	23, 27	29	26, 31	26	24, 28	29	26, 32	0·06	0·53
Red and processed meat‖										
Women	72	66, 76	76	73, 81	75	71, 79	55	52, 58	<0·001	<0·001
Men	115	109, 121	123	117, 129	123	118, 130	109	104, 115	0·017	0·008

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Table 2. (*Continued*)

Legume quartiles (g/d)	Q1		Q2		Q3		Q4		*P*-value† energy-adjusted model	P-value‡ multivariable model
	Quartile median*	Range	Quartile median*	Range	Quartile median*	Range	Quartile median*	Range		
Sugar-sweetened beverages‖										
Women	28	25, 31	26	23, 29	26	24, 29	20	18, 23	<0·001	<0·001
Men	38	34, 43	41	37, 47	38	34, 43	37	33, 42	0·50	0·53
Chocolate and sweets‖										
Women	10·3	9·6, 11·1	10·7	10·0, 11·5	10·2	9·5, 10·9	9·6	8·9, 10·3	0·043	<0·001
Men	9·5	8·8, 10·2	9·7	9·0, 10·5	8·6	8·0, 9·3	9·0	8·4, 9·7	0·25	0·028

Q, quartile.
* Quartile medians (g/d) are not adjusted for energy intake since energy (kJ/d) was used in the model.
† The *P* values for the energy-adjusted model were obtained from multivariable linear regression using each food as a continuous dependent variable at time and the median of each legume quartile and energy (kJ/d) as continuous independent variables. *P* values are significant below 0·050.
‡ The *P* values for the multivariable model were obtained from multivariable linear regression using each food as a continuous dependent variable and the median of each legume quartile, energy (kJ/d), age and BMI (kg/m²) as continuous independent variables and education, smoking, physical activity as categorical independent variables. *P* values are significant below 0·050.
§ The geometric means were calculated using legume quartiles as a categorical variable, including each food and energy (kJ/d), as a continuous variable in the analysis of the covariance.
‖ To conduct log transformation and geometric means, '1' was added to these variables, as they included zero consumption values.

thiamine, Mg, Fe, Zn and iodine in both models for both sexes. For example, the difference in the mean folate intake among women between the highest and lowest legume quartile was 93 μg/d. Among men, this difference was 79 μg/d, respectively. Legume consumption was also positively associated with MUFA intake (only among men) in the energy-adjusted model that attenuated to non-significant in the fully adjusted model. A positive association was also observed for riboflavin, but this changed to non-significant in men in the fully adjusted model. Higher legume consumption had a positive association with vitamin B_{12} intake only in men. Legume consumption was also positively associated with salt intake.

On the other hand, there was a negative association between legume consumption and the intake of some nutrients such as SAFA and sucrose (for sucrose only significant among women). For instance, the difference in the mean SAFA intake between women in the lowest and highest quartile of legume consumption was 2·2 g/d. Among men, this difference was 1·8 g/d, respectively. Among the vitamins studied, legume consumption and vitamin D levels had a negative association among women in the energy-adjusted model. This difference attenuated to non-significant in the multivariable model. Overall, the differences in the results between the energy-adjusted model and multivariable model were small (Tables 2 and 3). However, in some cases, adjusting for socio-demographic and lifestyle variables changed the associations to non-significant or vice versa as described above.

Discussion

Higher consumption of vegetables, fruits and berries and lower consumption of red and processed meat were observed at the higher legume consumption levels. These differences in food consumption were also reflected in differences in the intake of nutrients between the legume consumption groups. Higher intake of fibre, folate and thiamine in women and men and riboflavin in women, as well as lower intake of saturated fatty acids and sucrose (for sucrose significant only in women), were observed at higher legume consumption levels.

Similar to earlier studies[7,17,18] one of the main findings of this study was that higher legume consumption was associated with healthier food choices. The highest quartile of legume consumers, regardless of their sex, consumed considerably more fruits and berries, vegetables, nuts, seeds and vegetable-based fat spreads and oil and less butter and butter-based fats spreads, as well as, red and processed meat, compared with the lowest quartile. In contrast to the findings of Mitchell *et al.*[18] regarding cereal consumption in the USA population, a negative association was observed between legume consumption and total cereals. Among those food group variables for which multinomial regression models were constructed, although the *P* values changed, the overall associations described with odd ratios showed essentially similar type of associations as seen in linear regression models. The results of the linear regression for those variables in question should be interpreted with caution.

The results of this study are in line with the findings of the Swedish study,[7] and a US study that legume consumption is positively associated with the intake of fibre, folate, Fe, potassium

Table 3. Energy and nutrient intakes by the quartiles of legume consumption (g/d) for women (*n* 2875) and men (*n* 2250) (energy-adjusted geometric means and their 95 % confidence intervals (CI))

	Q1†		Q2		Q3		Q4			
Legume quartiles (g/d)	Quartile median*	Range	Quartile median*	Range	Quartile median*	Range	Quartile median*	Range	*P*-value† for energy-adjusted model	*P*-value‡ for multivariable model
Women	3·04	≤5·09	6·78	5·10–8·88	11·33	8·89–15·66	25·99	≥15·67		
Men	3·31	≤5·76	7·51	5·77–9·61	12·18	9·62–15·70	25·80	≥15·71		
	Mean§	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI		
Energy (MJ/d)‖										
Women	6·40	6·25, 6·55	7·38	7·21, 7·55	8·00	7·82, 8·19	8·32	8·13, 8·51	<0·001	<0·001
Men	8·04	7·83, 8·26	8·82	8·59, 9·06	9·41	9·16, 9·67	10·57	10·29, 10·86	<0·001	<0·001
Protein (g/d)										
Women	78·0	76·9, 79·1	82·1	81·1, 83·2	83·3	82·2, 84·3	83·2	82·0, 84·3	<0·001	<0·001
Men	95·9	94·4, 97·5	99·2	97·7, 100·9	102·4	100·9, 104	104·9	103·3, 106·7	<0·001	<0·001
Fat (g/d)										
Women	71·8	71·0, 72·8	74·3	73·5, 75·2	90·2	88·9, 91·6	87·9	86·7, 89·3	0·62	0·73
Men	86·7	85·3, 87·9	89·0	87·7, 90·4	74·5	73·6, 75·3	72·0	71·1, 72·9	0·12	0·08
SAFA (g/d)										
Women	27·1	26·7, 27·5	27·5	27·0, 27·9	27·0	26·6, 27·5	24·9	24·5, 25·3	<0·001	<0·001
Men	33·6	33·0, 34·2	33·8	33·2, 34·4	33·8	33·2, 34·4	31·8	31·2, 32·4	<0·001	<0·001
MUFA (g/d)										
Women	25·1	24·7, 25·5	26·2	25·8, 26·6	26·4	26·0–26·8	25·8	25·4, 26·2	0·37	0·71
Men	30·4	29·9, 30·9	31·6	31·1, 32·1	32·2	31·7–32·7	31·6	31·1, 32·1	0·016	0·25
PUFA (g/d)										
Women	11·5	11·3, 11·7	12·3	12·1, 12·5	12·7	12·5, 12·9	13·2	12·9, 13·4	<0·001	<0·001
Men	13·4	13·2, 13·7	14·1	13·9, 14·4	14·7	14·5, 15·0	15·1	14·8, 15·3	<0·001	<0·001
Carbohydrates (g/d)										
Women	173	170·2, 175·0	173·2	171·0, 175·4	173·9	171·4, 176·2	170·9	168·7, 173·4	0·16	0·61
Men	205	201·8, 208·4	208·5	205·1, 211·8	208·0	204·6, 211·3	202·6	199·5, 206·1	0·08	0·33
Total sugars (g/d)										
Women	82·2	80·5, 83·9	80·5	78·9, 82·0	82·3	80·7, 83·9	81·3	79·8, 83·0	0·77	0·82
Men	93·8	91·6, 96·2	93·5	91·4, 95·7	92·2	90·2, 94·4	93·3	91·2, 95·7	0·82	0·98
Sucrose (g/d)										
Women	32·0	31·0, 32·9	30·5	29·6, 31·3	31·2	30·3, 32·1	29·3	28·4, 30·1	<0·001	<0·001
Men	35·2	33·9, 36·6	34·7	33·4, 36·0	33·9	32·7, 35·2	33·5	32·2, 34·8	0·07	0·17
Fibre (g/d)										
Women	17·5	17·1, 17·9	19·4	19·0, 19·8	20·7	20·2, 21·1	23·0	22·5, 23·6	<0·001	<0·001
Men	17·8	17·3, 18·3	19·3	18·7, 19·8	21·3	20·7, 21·8	22·7	22·1, 23·3	<0·001	<0·001
Vitamin A (μg/d)										
Women	749	731, 767	844·9	826, 865	923·7	902, 946	1006	984, 1030	<0·001	<0·001
Men	821	798, 845·3	904·3	879, 931	994·3	966, 1023	1096	1064, 1127	<0·001	<0·001
Vitamin E (mg/d)										
Women	9·0	8·9, 9·2	9·7	9·5, 9·9	10·2	10·0, 10·4	10·8	10·6, 11·0	<0·001	<0·001
Men	9·7	9·5, 9·9	10·3	10·1, 10·5	10·9	10·6, 11·1	11·4	11·2, 11·7	<0·001	<0·001
Vitamin D (μg/d)										
Women	10·8	10·5, 11·5	11·1	10·8, 11·4	11·2	10·9, 11·5	10·4	10·1, 10·7	0·003	0·06
Men	12·5	12·1, 12·9	13·0	12·6, 13·5	13·5	13·1, 13·9	12·9	12·5, 13·3	0·43	0·20
Folate (μg/d)										
Women	239	235, 243	264	259, 268	285	280, 290	332	327, 337	<0·001	<0·001
Men	269	265, 274	290	285, 295	310	305, 315	348	342, 354	<0·001	<0·001

Table 3. (*Continued*)

Legume quartiles (g/d)	Q1† Quartile median*	Q1† Range	Q2 Quartile median*	Q2 Range	Q3 Quartile median*	Q3 Range	Q4 Quartile median*	Q4 Range	*P*-value† for energy-adjusted model	*P*-value‡ for multivariable model
Riboflavin (mg/d)										
Women	1·8	1·8, 1·9	1·9	1·8, 1·9	1·9	1·8, 1·9	1·9	1·8, 1·9	0·036	0·039
Men	2·1	2·1, 2·2	2·1	2·1, 2·2	2·2	2·2, 2·3	2·2	2·2, 2·3	0·009	0·09
Thiamine (mg/d)										
Women	1·3	1·3, 1·3	1·4	1·3, 1·4	1·4	1·4, 1·4	1·5	1·4, 1·5	<0·001	<0·001
Men	1·6	1·6, 1·6	1·7	1·7, 1·7	1·7	1·7, 1·8	1·8	1·8, 1·8	<0·001	<0·001
Vitamin B_{12} (μg/d)										
Women	6·0	5·8, 6·1	6·3	6·2, 6·5	6·5	6·4, 6·7	6·2	6·0, 6·4	0·46	0·52
Men	7·4	7·2, 7·6	7·9	7·7, 8·1	8·3	8·1, 8·5	8·6	8·4, 8·9	<0·001	<0·001
Vitamin C (mg/d)										
Women	93	89, 97	104	100, 108	118	113, 123	148	142, 155	<0·001	<0·001
Men	98	95, 101	113	109, 117	132	128, 137	160	154, 165	<0·001	<0·001
Ca (mg/d)										
Women	1059	1035, 1086	1086	1059, 1112	1071	1045, 1096	1076	1051, 1101	0·66	0·51
Men	1226	1191, 1262	1213	1178, 1247	1249	1213, 1285	1234	1197, 1271	0·60	0·88
Potassium (mg/d)										
Women	3596	3548, 3647	3784	3732, 3837	3932	3881, 3990	4127	4074, 4188	<0·001	<0·001
Men	4114	4055, 4178	4310	4246, 4375	4480	4416, 4550	4727	4656, 4797	<0·001	<0·001
Mg (mg/d)										
Women	347	343, 352	364	359, 369	371	366, 376	389	384, 394	<0·001	<0·001
Men	398	392, 404	417	412, 424	429	423, 434	439	432, 445	<0·001	<0·001
Salt (g/d)										
Women	6·2	6·1, 6·3	6·6	6·5, 6·6	6·7	6·6, 6·8	6·7	6·6, 6·8	<0·001	<0·001
Men	7·9	7·8, 8·02	8·3	8·2, 8·4	8·6	8·4, 8·7	8·6	8·5, 8·7	<0·001	<0·001
Fe (mg/d)										
Women	9·2	9·1, 9·4	10·0	9·9, 10·2	10·5	10·4, 10·7	11·5	11·4, 11·7	<0·001	<0·001
Men	10·7	10·6, 10·9	11·4	11·3, 11·6	12·2	12·0, 12·4	13·1	12·9, 13·3	<0·001	<0·001
Zn (mg/d)										
Women	10·4	10·3, 10·5	10·9	10·8, 11·0	11·1	10·9, 11·2	11·0	10·9, 11·2	<0·001	<0·001
Men	12·7	12·5, 12·9	13·1	12·9, 13·3	13·6	13·4, 13·8	13·6	13·4, 13·8	<0·001	<0·001
Iodine (μg/d)										
Women	206	203, 209	216	213, 219	220	217, 223	221	217, 224	<0·001	<0·001
Men	248	244, 253	260	255, 264	270	265, 275	272	268, 277	<0·001	<0·001
Alcohol (ethanol g/d)										
Women	2·8	2·7, 3·0	3·3	3·1, 3·6	3·2	3·0, 3·4	3·1	2·9, 3·3	0·50	0·58
Men	5·8	5·3, 6·4	6·8	6·2, 7·4	6·8	6·2, 7·4	5·8	5·2, 6·3	0·29	0·19

Q, quartile.
* Quartile medians (g/d) are not adjusted for energy intake since energy (kJ/d) was used in the model.
† The *P* values for the energy-adjusted model were obtained from multivariable linear regression using each nutrient as a continuous dependent variable at time and the median of each legume quartile and energy (kJ/d) as continuous independent variables. *P* values are significantly below 0·050.
‡ The *P* values for the multivariable model were obtained from multivariable linear regression using each nutrient as a continuous dependent variable and the median of each legume quartile (continuous), energy (kJ/d), age and BMI(kg/m²) as continuous independent variables and education, smoking, physical activity as categorical independent variables. *P* values are significantly below 0·050.
§ The geometric means were calculated using legume quartiles as a categorical variable, including each food and energy (kJ/d), as a continuous variable in the analysis of the covariance.
|| The values for energy variable are not additionally adjusted for energy.

and Mg. Unlike the findings of a US study that observed a negative association for riboflavin and no change in thiamine intake between the highest legume consumption and the non-consumers[20], our findings showed that legume consumption was positively associated with the intake of thiamine and riboflavin (for riboflavin only in women). These findings are of importance, since compared with the average requirements for vitamins and nutrients, at least one-fifth of the Finnish population has insufficient intake of folate, riboflavin and thiamine. Furthermore, among the Finnish adult population, fibre and carbohydrate intakes are lower than recommended in two-thirds of the population[9]. Interestingly, higher legume consumption was positively associated with vitamin B_{12} intake among men. This could be partially explained by the higher consumption of other animal products such as fish and cheese among men across quartiles. Unlike Mitchell *et al.*,[18], our findings revealed a significantly positive association between legume consumption and PUFA intake. Similar to our findings, the Canadian study[17] reported higher intake of PUFA and MUFA among legume consumers and the highest in the third quartile compared with non-consumers. Based on our results, higher legume consumption was positively associated with MUFA intake only among men in the energy-adjusted model. These associations suggest that in the Finnish food culture higher legume consumption goes along with better food choices (food group results) and better nutrient intake profile (nutrient results). Therefore, the adoption of such diets more widely has the potential to improve public health nutrition. However, this needs to be further studied in different research settings.

Regarding nutrients that are of concern in the diet of the Finnish adult population, salt intake was significantly higher in the highest legume quartile in the present study. Similar findings have been observed by the Canadian study[17]. This could be possibly due to the generally high salt content in the Finnish legume food recipes and new legume-based meat alternatives, in addition to the salt content of the other food groups that are positively associated with legume consumption. Moreover, based on the findings of this study, the iodine intake was significantly higher in the highest quartile. Another potential concern is the lower vitamin D intake among women in the highest quartile compared with the lowest quartile (significant only in energy-adjusted model). This could be partly explained by the significantly lower consumption of liquid milk products among the women in the highest quartile of legume consumption since fortified milk products are one of the major food sources of vitamin D in Finland. Among men, although vitamin D intake increased across quartiles (highest in the third quartile), the association was not statistically significant.

Legume consumption might vary across demographic groups in different populations. There was a negative association between legume consumption and age in both men and women. Most previous studies examining legume consumption and age, however, have reported a positive association[7,17–19]. On the other hand, a US study [20] showed that most of the legume consumers are aged 31–70 years. In contrast, among the Canadian population,[17] no association was found when adjusted for energy intake. Contrary to the US studies [18–20] and similar to the Swedish population[7], there was a positive association between legume consumption and level of education. However, most of the Swedish participants had a level of education higher than the elementary level, and their legume quartiles were adjusted for energy intake when assessing the socio-demographic and lifestyle characteristics[7]. Our findings showed that legume consumption was positively associated with leisure-time physical activity, but no association was found with smoking and BMI. The present study was the only study that examined the association between legume consumption and leisure-time physical activity and considered it as a confounder. In line with earlier findings in Sweden and Canada[7,17], although the total energy intake was higher in the highest quartile of legume consumption, BMI did not differ significantly across the quartiles of legume consumption. Our results could be partially explained by the higher intake of healthier food groups and higher leisure-time physical activity in the highest quartile. Overall, more research is needed to confirm these findings, especially regarding age, educational level and physical activity. Our results suggest that legume consumption might vary across demographic groups across the Finnish population. In fact, it has been reported that the highest educated group in Finland obtains more nutrients not only from vegetables, fruit and berries but also from legumes and nuts compared with the lowest educated group[35].

There are several differences between this study and previous studies. Earlier studies utilised methods of data collection other than FFQ for nutritional data, such as 24 h dietary recall. Hence, they compared consumers to non-consumers as well as across consumption quartiles and reported absolute intakes. Despite the use of different methods, meaningful and similar associations were identified. Additionally, due to considerable variations in the dietary guidelines of countries, legumes are categorised differently in the literature. The Canadian[17] and USA studies[18–20] looked specifically at pulses (dry legume grains), whereas the Swedish study[7] included pulses, fresh legumes, peanuts, soya products, sprouts and mixed meals with legumes in their study. In our study, all types of legumes currently consumed were considered, due to overall low legume consumption in this population. It is important to note that food pattern and food culture differences might account for differences between the studies.

A limitation of this study is the self-reported data; hence, there is a possibility for over- and under-reporting. Another limitation is the lack of absolute measures, as we utilised FFQ and semi-quantitative data. Therefore, we were not able to compare our results with recommendations and dietary guidelines. Nevertheless, FFQ is the most appropriate method for assessing dietary habits over a long period for epidemiological study purposes and is designed for studies concentrating on the association of diet with various health outcomes[36]. The strengths of this study are the validated FFQ, the large population-based sample, as well as measured body weight and height. Additionally, the data collected for the FinHealth 2017 were detailed and varied, allowing us to consider several food and nutrient variables and confounders in this study. The relatively high participation rate (58 %) in this study, in comparison with other international studies, increases the generalisability of these findings to the Finnish adult population. Moreover, the present study was the only study that adjusted the association between legume consumption and food groups and nutrients for central socio-demographic and lifestyle confounders.

Overall, in line with the results for food groups, legume consumption is associated with better nutrient intake profile in the Finnish adult population. The results thus reinforce the general view that diets with higher legume consumption appear to be more balanced. In some cases, when the association was additionally adjusted for socio-demographic and lifestyle confounders, the associations lost their significance such as in cheese or gained significance for potato and chocolates and sweets (both among men). Therefore, these confounders are central when studying diet and dietary patterns. Moreover, the results have implications for the planning of future epidemiological research on the associations of legume consumption and health outcomes and their interpretation.

In conclusion, more uniform studies are needed from Nordic countries on legume consumption to confirm recent findings regarding the association of legumes with other healthy and less healthy aspects of diets. Additionally, this study offers important background information for planning intervention studies and programs as well as stakeholders wishing to increase legume consumption. For instance, health policy actions or future interventions could benefit from these results. Overall, increasing legume consumption is an important goal, also from the food system perspective. Legumes maintain ethical synergies by contributing to nutrition security while promoting human health as well as having beneficial environmental impact[37]. Characterising legume consumers can play an important role in increasing public health knowledge of legume consumption and improving national and international dietary recommendations.

Conclusions

Overall, our findings suggest higher legume consumption has positive association with the consumption of foods considered healthy as well as nutrient intake profile, in the adult population of Finland. At the same time, higher legume consumption is associated with higher salt intake in both women and men. Increased legume consumption appears to be also associated with higher education and a healthier lifestyle. Additionally, taking into consideration the potential of legumes in Finnish food system and agriculture[38] and according to the EAT Lancet Commissions guidelines[8], the production and consumption of legumes in the general adult population of Finland need to be promoted and increased. The practical relevance of our findings needs to be elucidated and studied further, e.g. in longitudinal settings, so that dietary recommendations for legumes could include better advice to mitigate or enhance their impacts.

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