Original Article

Tree nut consumption improves nutrient intake and diet quality in US adults: an analysis of National Health and Nutrition Examination Survey (NHANES) 1999-2004

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Recent epidemiologic studies assessing tree nut (almonds, Brazil nuts, cashews, hazelnuts, macadamia nuts, pecans, pine nuts, pistachios, and walnuts) consumption and the association with nutrient intake and diet quality are lacking. This study determined the association of tree nut consumption and nutrient intake and diet quality using a nationally representative sample of adults. Adults 19+ years (y) (n=13,292) participating in the 1999-2004 National Health and Nutrition Examination Survey were used. Intake was determined from 24-hour diet recalls; tree nut consumers were defined as those consuming ≥¼ ounce/day (7.09 g). Means, standard errors, and ANOVA (adjusted for covariates) were determined using appropriate sample weights. Diet quality was measured using the Healthy Eating Index-2005. Among consumers, mean intake of tree nuts/tree nut butters was 1.19 ± 0.04 oz/d versus 0.01 ± 0.00 oz/d for non-consumers. In this study, 5.5 ± 0.3 % of individuals 19-50 y (n=7,049) and 8.4 ± 0.6 % of individuals 51+ y (n=6,243) consumed tree nuts/tree nut butters. Mean differences (p<0.01) between tree nut consumers and non-consumers of adult shortfall nutrients were: fiber (+5.0 g/d), vitamin E (+3.7 mg AT/d), calcium (+73 mg/d), magnesium (+95 mg/d), and potassium (+260 mg/d). Tree nut consumers had lower sodium intake (-157 mg/d, p<0.01). Diet quality was significantly higher in tree nut consumers (58.0±0.4 vs. 48.5±0.3, p<0.01). Tree nut consumption was associated with a higher overall diet quality score and improved nutrient intakes. Specific dietary recommendations for nut consumption should be provided for consumers.

Key Words: tree nuts, nutrient intake, dietary adequacy, healthy eating index-2005, NHANES

INTRODUCTION

Almonds, Brazil nuts, cashews, hazelnuts, macadamia nuts, pecans, pine nuts, pistachios, and walnuts are defined as tree nuts. Tree nuts have been a part of the human diet for thousands of years;[1] however, they no longer constitute a staple part of the diet. Tree nuts are high in energy, and although individual species vary in nutrient composition, they are rich sources of vegetable protein, monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), dietary fiber, vitamins E and K, folate, magnesium, copper, selenium, and potassium. Tree nuts are low in saturated fatty acids (SFA) and sodium (unless added during processing).[2] Tree nuts are also rich sources of phytonutrients, including phytosterols, flavonoids, and proanthocyanidins.[3,4] Many of these compounds are anti-inflammatory,[5] and may provide the health benefits associated with consumption of tree nuts.

Tree nuts have been shown to be associated with a wide range of health benefits, including reduced levels of coronary heart disease,[6-9] hypertension,[10] type 2 diabetes,[11] and obesity.[12] In 2003, the Federal Food and Drug Administration released the first qualified health claim for nuts: "Scientific evidence suggests but does not prove that eating 1.5 ounces per day of most nuts [such as *name of specific nut*], as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease. [See nutrition information for fat content]."[13]

Despite their health benefits, recommendations for consumption of tree nuts are not clear. MyPyramid places nuts and seeds together with meat and beans;[14] although there are significant differences in the nutrient profiles.[2] Nut consumption is encouraged to increase intake of MUFA and vitamin E; however, no specific recommendations are given. The Adult Treatment Plan III of the National Heart Lung and Blood Institute acknowledges

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the role of nuts in a healthy diet, but merely advocates that nuts should fit the energy and fat goals.[15] The Dietary Approaches to Stop Hypertension diet recommends 4-5 servings of nuts, seeds, or legumes per week to reduce blood pressure.[16] Nuts are also an important part of the Mediterranean food pattern. In the original Mediterranean food guide pyramid, nuts, along with legumes and seeds, constituted a separate food group; however, in the pattern released in 2009, nuts are grouped with all plant foods.[17] Without specific guidance, it is difficult for individuals to understand dietary recommendations.

Current consumption of nuts in the US is not well defined. The 1994-1996 Continuing Survey of Food Intakes by Individuals (CSFII) showed that 12% of males and 14% of females consumed tree nuts; consumption was more common in adults over the age of 40 (15%) than in younger adults and children (11%).[18] Tree nuts were consumed mainly as snacks (51%), followed by consumption at breakfast/brunch (24%). In adults 20-39, 40-59, and 60+ years (y) of age, the prevalence of consumption was 11%, 15%, and 15%, respectively. In those age groups, per capita consumption of tree nuts was 1.0, 1.6, and 1.2 grams/day, respectively.[18] Food availability data from the Economic Research Service suggests that consumption of tree nuts increased by 45% from 1995 to 2005;[19] however, since these are not consumption data, it is not clear if the prevalence of consumption increased or if the *per capita* consumption increased. King *et al.*[20] in a brief report of What We Eat in America 2001-2004 reported that nuts (including tree nuts and peanuts) were consumed by 34% of the population in snacks, peanut butter, or as ingredients in recipes. Average consumption of nuts was 7.3 g/d, and peanuts were the most frequently consumed "nut." In Europe, the European Prospective Investigation into Cancer and Nutrition (EPIC) cohorts showed that in the 10 participating countries, total tree nut consumption was 1.13 g/d with 4.4% of the population consuming tree nuts.[21] There was a clear north to south increase in tree nut consumption, possibly reflecting cultural preferences or food availability.

No recent studies using a nationally representative US population have examined the prevalence of tree nut consumption and the association of consumption with diet. The objective of this study was to determine consumption levels and the association of tree nut consumption with nutrient intake and diet quality.

SUBJECTS AND METHODS

Study population

Data from adults 19 y and older participating in the National Health and Nutrition Examination Surveys (NHANES) 1999-2000, 2001-2002, and 2003-2004 were combined for these analyses. Intake data were obtained from 24 hour recalls; recall data judged to be incomplete or unreliable by National Center for Health Statistics staff were excluded from analyses. Detailed descriptions of the dietary interview methods are provided in the NHANES Dietary Interviews Procedure Manual, which includes pictures of the Computer-Assisted Dietary Interview system screens, measurement guides, and charts used to collect dietary information.[22] Pregnant or lactating females were excluded from the sample. This study was exempted by the LSU AgCenter Institutional Review Board.

Food composition data

The source of food composition data used to determine the gram amounts of tree nuts contained in survey foods was either the SR-Link file (the recipe database) of the Food and Nutrient Database for Dietary Studies (FNDDS),[23] or the USDA Food Commodity Intake Database (FCID).[24] The Nutrient Database for Standard Reference (SR) codes in the SR-Link file and commodity codes in the FCID were used to identify ingredients of survey foods that included the following tree nuts, or butters made from the following tree nuts: almonds, Brazil nuts, cashews, hazelnuts, macadamias, pecans, pistachios, walnuts, and pine nuts.

The gram amount of tree nuts and tree nut butters consumed was determined by applying the nut composition database to the respondent's 24-hour recall. The tree nut content per 100 grams was multiplied by the gram weight of the food consumed divided by 100. Tree nut intakes from each food consumed were aggregated over the entire day. Tree nut consumption was defined by intakes of at least ¼ ounce (7.09 grams) per day; non-consumers had an intake of less than ¼ ounce tree nuts per day.

The NHANES, 1999-2000, database does not include intakes of vitamin A (RAE), α-tocopherol (mg), and vitamin K (μg). Nutrient composition data for foods in the USDA FNDDS were used to add the intakes of vitamin K (μg) to the NHANES, 1999-2000, nutrient intake database. Similar foods were used in place of 140 survey foods that were missing from the FNDDS. The vitamin A (RAE) and α-tocopherol (mg) content of all survey foods consumed were available from the USDA Database of Vitamin A (mcg RAE) and Vitamin E (mg AT) for NHANES 1999-2000. Food composition data to calculate MyPyramid food group intakes were obtained from the MyPyramid Equivalents Database for USDA Survey Food Codes, 1994-2002, Version 1.0[25] and for 2003-2004, Version 2.0.[23] The equivalents content per 100 grams was multiplied by the gram weight of food consumed divided by 100. The MyPyramid equivalents intake from foods consumed were aggregated over the entire day to calculate the MyPyramid equivalents intake per day. The new Healthy Eating Index (HEI-2005) was used to determine diet quality.[26-28] The whole fruit food composition data and SAS code used to calculate HEI-2005 scores were downloaded from the Center for Nutrition Policy and Promotion website.[29]

Statistical analysis

Sample-weighted data were used and all analyses were performed using SUDAAN Release 9.0.1 (Research Triangle Institute, Research Triangle Park, NC) to adjust the variance for the complex sample design. For the 6-years 1999-2004, a 6-year weight variable was created by assigning 2/3 of the 4 year weight for 1999-2002 if the person was sampled in 1999-2002 or assigning 1/3 of the 2 year weight for 2003-2004 if the person was sampled in 2003-04.

The sample-weighted percentages (and standard error of the percentages) of adults in nut consumption groups

were calculated using PROC CROSSTAB of SUDAAN. Least-square means (and the standard errors of the least-square means) were calculated using PROC REGRESS of SUDAAN.

Least-square mean intakes were adjusted for energy (Kcal), gender, age (years), and race-ethnicity. Gender, age (years), and race-ethnicity were covariates in the analysis of least-square mean energy intake.

RESULTS

Among adults 19+ y, mean intake of tree nuts/tree nut butters for consumers was 1.19 ± 0.04 oz/d versus 0.01 ± 0.00 oz/d for non-consumers (data not shown). In this study, 5.5 ± 0.3 % of individuals 19-50 years (n=7,049) and 8.4 ± 0.6 % of individuals 51+ years (n=6,243) consumed tree nuts/tree nut butters. Table 1 shows the demographic distribution of tree nut consumers and non-consumers. Tree nuts were significantly more likely to be consumed by adults 19-50 years of age, whites, and those individuals with a higher income and more education ($p<0.01$); there was no difference in tree nut consumption between the genders.

Nutrient and food group intake

Nutrient intake by consumers and non-consumers of tree nuts/tree nut butters is shown in Table 2. Energy intake was higher for tree nut consumers than non-consumers (10750 ± 201 vs. 9180 ± 46 kJ/d, $p<0.01$); thus, subsequent analyses of nutrient intake were also adjusted for energy intake. Tree nut consumers had significantly higher intakes of total fat; MUFA; PUFA; fiber; vitamins A, E, K, B-6, and C; thiamin; riboflavin; folate; calcium; phosphorus; magnesium; iron; zinc; copper; and potassium ($p<0.01$ for all except calcium $p<0.05$) than non-consumers. In addition, consumers had lower intakes of carbohydrates, alcohol, and sodium ($p<0.01$) than non-consumers of tree nuts.

Tree nut consumers had greater ($p<0.01$) intakes of MyPyramid food groups (Table 3) such as total fruit, whole fruit, dark green/orange vegetables, whole grains, meat equivalents, nuts/seeds, and oils, and lower ($p<0.01$) intakes of total grains, meat/poultry/fish, solid fat and added sugars as compared to non-consumers. Energy intake from solid fat, alcohol, and added sugars (SoFAAS) was significantly lower ($p<0.01$) in tree nut consumers compared with non-consumers. In addition, tree nut consumers had a higher ($p<0.01$) total HEI-2005 score than non-consumers (58.8 ± 0.6 vs. 49.5 ± 0.3) (Table 4). All component scores, with the exception of total vegetables, milk, and SFA were significantly higher ($p<0.01$) in tree nut consumers than non-consumers.

Table 1. Demographic distribution of the population by consumption of tree nuts and tree nut butters

Demographic Group	Ages 19+ Yr (n = 13,292)			Tree Nuts & Tree Nut Butters					
				≥1/4 oz (7.09 g) (n = 749)			< 1/4 oz (7.09 g) (n = 12,543)		
	Pct	± SE	Sample n	Pct	± SE	Sample n	Pct	± SE	Sample n
Age group *									
19-50 years	62.5	± 0.9	7,049	52.3	± 2.4	314	63.2	± 0.8	6,735
51+ years	37.5	± 0.9	6,243	47.7	± 2.4	435	36.8	± 0.8	5,808
Gender									
Male	49.2	± 0.4	6,747	49.9	± 2.1	394	49.2	± 0.5	6,353
Female	50.8	± 0.4	6,545	50.1	± 2.1	355	50.8	± 0.5	6,190
Ethnicity *									
White, non-Hispanic	72.7	± 1.7	6,613	83.9	± 2.0	489	71.9	± 1.8	6,124
Black, non-Hispanic	10.8	± 1.0	2,702	5.7	± 1.0	94	11.2	± 1.0	2,608
Mexican American & Other Hispanic	12.8	± 1.6	3,620	7.4	± 1.2	150	13.2	± 1.6	3,470
Other, incl. multi-racial	3.7	± 0.4	357	3.0	± 0.7	16	3.7	± 0.4	341
Education *									
Less than High School	20.6	± 0.7	4,399	10.2	± 1.6	137	21.3	± 0.7	4,262
HS Diploma or GED	26.5	± 0.8	3,235	20.8	± 1.7	157	26.9	± 0.8	3,078
More than High School	53.0	± 1.0	5,633	69.0	± 2.2	455	51.8	± 1.0	5,178
Poverty Income Ratio *									
≤100%	13.2	± 0.7	2,376	6.0	± 1.0	72	13.7	± 0.7	2,304
101-185%	17.2	± 0.8	2,875	11.8	± 1.1	111	17.6	± 0.8	2,764
186-350%	23.6	± 0.7	3,064	19.9	± 1.8	161	23.9	± 0.7	2,903
>350%	38.6	± 1.3	3,811	56.4	± 2.5	349	37.4	± 1.3	3,462
Income not reported	7.4	± 0.6	1,166	6.0	± 1.3	56	7.5	± 0.6	1,110

Source: NHANES, 1999-2004, adults 19 years and older, excluding pregnant or lactating females
Sample-weighted percentage and standard error are estimated using PROC CROSSTAB of SUDAAN.
* Chi-square test was significant at $p<0.01$

Table 2. LS-mean daily nutrient intake by consumption of tree nuts and tree nut butters

Nutrient	Ages 19+ Yr (n = 13,292)	Tree Nuts & Tree Nut Butters		
		≥1/4 oz (7.09 g) (n = 749)		<1/4 oz (7.09 g) (n = 12,543)
Food energy (kJ)	9285 ± 42	10750 ± 201	**	9180 ± 46
Food energy (Kcal)	2218 ± 10	2568 ± 48	**	2193 ± 11
Protein (g)	82.3 ± 0.4	83.7 ± 1.8		82.2 ± 0.4
Total fat (g)	83.0 ± 0.4	93.5 ± 1.3	**	82.3 ± 0.4
Saturated fat (g)	27.2 ± 0.1	26.9 ± 0.6		27.3 ± 0.1
Monounsaturated fat (g)	31.1 ± 0.2	37.2 ± 0.5	**	30.7 ± 0.2
Polyunsaturated fat (g)	17.2 ± 0.1	21.7 ± 0.4	**	16.9 ± 0.1
Cholesterol (mg)	289 ± 3	276 ± 11		290 ± 3
Carbohydrate (g)	273 ± 1	262 ± 3	**	274 ± 1
Total dietary fiber (g)	15.7 ± 0.2	20.3 ± 0.5	**	15.3 ± 0.2
Alcohol (g)	11.9 ± 0.5	6.8 ± 1.2	**	12.2 ± 0.5
Vitamin A (g RAE)	611 ± 10	729 ± 27	**	602 ± 10
Alpha Tocopherol (mg)	7.1 ± 0.1	10.5 ± 0.3	**	6.8 ± 0.1
Vitamin C (mg)	92.5 ± 1.8	106.0 ± 5.2	**	91.6 ± 1.8
Vitamin K (mcg)	90.6 ± 2.2	134.9 ± 7.7	**	87.4 ± 2.2
Thiamin (mg)	1.64 ± 0.01	1.75 ± 0.04	**	1.63 ± 0.01
Riboflavin (mg)	2.14 ± 0.02	2.28 ± 0.05	**	2.14 ± 0.02
Niacin (mg)	23.6 ± 0.2	23.6 ± 0.5		23.6 ± 0.2
Vitamin B-6 (mg)	1.87 ± 0.02	2.11 ± 0.07	**	1.85 ± 0.02
Total folate (mcg)	398 ± 4	446 ± 14	**	395 ± 4
Vitamin B-12 (mcg)	5.2 ± 0.1	5.1 ± 0.3		5.2 ± 0.1
Calcium (mg)	857 ± 7	925 ± 27	*	852 ± 8
Phosphorus (mg)	1328 ± 6	1474 ± 26	**	1317 ± 6
Magnesium (mg)	283 ± 2	372 ± 5	**	277 ± 2
Iron (mg)	15.6 ± 0.1	16.8 ± 0.3	**	15.5 ± 0.1
Zinc (mg)	12.0 ± 0.1	12.8 ± 0.3	**	11.9 ± 0.1
Copper (mg)	1.31 ± 0.01	1.84 ± 0.03	**	1.27 ± 0.01
Sodium (mg)	3464 ± 17	3179 ± 58	**	3484 ± 17
Potassium (mg)	2747 ± 17	2990 ± 38	**	2730 ± 18

Source: NHANES, 1999-2004, ages 19 years and older, excluding pregnant/lactating females.
Sample-weighted least-square mean and standard error are estimated using PROC REGRESS of SUDAAN.
Covariates with nutrients include energy (Kcal), gender, race-ethnicity, and age (years).
Gender, race-ethnicity, and age (years) were covariates with energy (Kcal).
Abbreviations: oz = ounce; g = gram; mg = milligram; mcg = microgram
* Nut consumption groups differ significantly at $p < 0.05$
** Nut consumption groups differ significantly at $p < 0.01$

DISCUSSION

These data indicate that the prevalence of tree nut and tree nut butter consumption by US adults was low, with only 5.5% and 8.4% of participants 19-50 y and 51+ y, respectively consuming these menu items. In this study, the average amount consumed on the day of the recall was 1.2 oz. The definition of nut consumption (≥¼ oz. (7.09 g)/day) used for this study was selected since small amounts of nuts are present in a wide variety of foods, including cookies, cereal bars, breads, and candies, and we did not want those who consumed small amounts of these foods to be included in the nut consumption group. The USDA defines an ounce equivalent as 0.5 ounces (approximately 4 g)[14] and per capita tree nut consumption was about 0.25 ounces (approximately 7 g/d); assuming intent, we chose to define tree nut consumers as those with ¼ ounce or more per day.

These consumption percentages were lower than those shown in the CSFII study,[18] although they are consistent with the age trend shown in that study. Reasons for these differences are not clear, but may reflect the use of two dietary recalls for CSFII[30] as compared with the single dietary recall used in this study. The percentage of consumers in this study was more consistent that observed in central (4.3%) and southern (6.3%) Europe.[21] The EPIC study also used a single 24 hour dietary recall.

Despite the relative low levels of consumption, tree nuts consumption was associated with improved nutrient intake and diet quality. Comparison of macronutrients suggested more favorable lipid intakes in tree nut consumers than in non-consumers, presumably due to the lipid profile of tree nuts.[31] Tree nuts are low in SFA and high in MUFA and PUFA, including omega-6 and omega-3 fatty acids [walnuts].[32] The absolute intake of

Table 3. LS-mean MyPyramid food group intake by consumption of tree nuts and tree nut butters

MyPyramid Food Group	Ages 19+ Yr (n = 13,292)	Tree Nuts & Tree Nut Butters					
		≥1/4 oz (7.09 g) (n = 749)			< 1/4 oz (7/09 g) (n = 12,543)		
Total fruit (cup)	1.01 ± 0.03	1.38 ± 0.06	**		0.98 ± 0.03		
Whole fruit (cup)	0.60 ± 0.02	0.93 ± 0.05	**		0.57 ± 0.02		
Total vegetables (cup)	1.62 ± 0.02	1.68 ± 0.07			1.62 ± 0.02		
Dark green/orange vegetables (cup)	0.19 ± 0.01	0.30 ± 0.02	**		0.18 ± 0.01		
Total grains (oz)	6.79 ± 0.06	6.08 ± 0.17	**		6.84 ± 0.06		
Whole grains (oz)	0.65 ± 0.02	0.92 ± 0.06	**		0.63 ± 0.02		
Milk group (cup)	1.57 ± 0.02	1.67 ± 0.09			1.56 ± 0.02		
Meat group (oz)	5.93 ± 0.06	7.77 ± 0.24	**		5.80 ± 0.06		
Meat/Poultry/Fish (oz)	4.85 ± 0.06	4.11 ± 0.19	**		4.90 ± 0.06		
Eggs (oz)	0.47 ± 0.01	0.52 ± 0.05			0.46 ± 0.01		
Soy products (oz)	0.05 ± 0.01	0.08 ± 0.02			0.05 ± 0.01		
Nuts & seeds (oz)	0.57 ± 0.02	3.06 ± 0.13	**		0.39 ± 0.02		
Legumes (cup)	0.11 ± 0.00	0.10 ± 0.01			0.12 ± 0.01		
Oils (gram)	18.0 ± 0.2	30.6 ± 0.9	**		17.1 ± 0.2		
Solid fat (gram)	47.9 ± 0.3	41.1 ± 0.9	**		48.4 ± 0.3		
Added sugars (tsp)	22.2 ± 0.4	18.0 ± 0.7	**		22.5 ± 0.4		
SoFAAS calories (Kcal)	893 ± 6	719 ± 16	**		906 ± 6		
SoFAAS calories (KJ)	3738 ± 25	3010 ± 67	**		3793 ± 25		
Solid fat calories (Kcal)	431 ± 3	370 ± 8	**		436 ± 3		
Solid fat calories (KJ)	1804 ± 13	1549 ± 33	**		1825 ± 13		
Added sugars calories (Kcal)	356 ± 6	288 ± 11	**		360 ± 6		
Added sugars calories (KJ)	1490 ± 25	1206 ± 46	**		1507 ± 25		
Alcohol calories (Kcal)	106 ± 4	60 ± 10	**		110 ± 5		
Alcohol calories (KJ)	444 ± 17	251 ± 42	**		460 ± 21		

Source: NHANES, 1999-2004, ages 19 years and older, excluding pregnant/lactating females.
Sample-weighted least-square mean and standard error are estimated using PROC REGRESS of SUDAAN.
Covariates include energy (Kcal), gender, race-ethnicity, and age (years).
Abbreviation: SoFAAS: Solid Fat, Alcohol, Added Sugars
Because this table shows results from the United States food guidance system (MyPyramid), the original units were retained. To convert the units: 1 US liquid cup = 236.6 ml; 1 US dry cup = 275.30 ml; 1 fluid ounce = 29.57 ml; 1 ounce = 28.35 g; 1 US teaspoon = 4.92 ml
* Nut consumption groups differ significantly at $p < 0.05$
** Nut consumption groups differ significantly at $p < 0.01$

Table 4. LS-mean HEI-2005 component score by consumption of tree nuts and tree nut butters

HEI-2005 Component Score (maximum)	Ages 19+ Yr (n = 13,292)	Tree Nuts & Tree Nut Butters					
		≥1/4 oz (7.09 g) (n = 749)			<1/4 oz (7/09 g) (n = 12,543)		
Total HEI-2005 Score (100)	50.1 ± 0.3	58.8 ± 0.6	**		49.5 ± 0.3		
Total fruit (5)	2.13 ± 0.05	2.55 ± 0.08	**		2.10 ± 0.05		
Whole fruit (5)	1.89 ± 0.05	2.48 ± 0.08	**		1.85 ± 0.05		
Total vegetables (5)	3.02 ± 0.02	2.96 ± 0.08			3.02 ± 0.02		
Dark green/orange vegetables & legumes (5)	1.18 ± 0.03	1.55 ± 0.09	**		1.15 ± 0.03		
Total grains (5)	4.16 ± 0.02	3.90 ± 0.08	**		4.18 ± 0.02		
Whole grains (5)	0.96 ± 0.02	1.18 ± 0.06	**		0.95 ± 0.02		
Milk (10)	4.74 ± 0.06	5.06 ± 0.20			4.72 ± 0.05		
Meat & Beans (10)	8.15 ± 0.04	9.12 ± 0.12	**		8.09 ± 0.05		
Oils (10)	5.32 ± 0.04	7.94 ± 0.10	**		5.14 ± 0.05		
Saturated fat (10)	5.95 ± 0.06	6.03 ± 0.19			5.94 ± 0.06		
Sodium (10)	4.20 ± 0.05	5.15 ± 0.14	**		4.13 ± 0.05		
SoFAAS calories (20)	8.38 ± 0.13	10.91 ± 0.33	**		8.21 ± 0.13		

Source: NHANES, 1999-2004, ages 19 years and older, excluding pregnant/lactating females.
Sample-weighted least-square mean and standard error are estimated using PROC REGRESS of SUDAAN.
Covariates include gender, race-ethnicity, and age (years).
* Nut consumption groups differ significantly at $p < 0.05$
** Nut consumption groups differ significantly at $p < 0.01$
SoFAAS = solid fat, alcohol, added sugars; since the program is designed to provide calories, this unit was used; 1 kilocalorie = 4.19 kilojoules

total grams of fat was higher in tree nut consumers than in non-consumers; however, the percent energy from fat in the diet was approximately equal: 32.8% in consumers and 33.8% in non-consumers. Thus, both consumers and non-consumers had mean fat intakes within the Acceptable Macronutrient Distribution Range of 20-35% of energy, set by the Institute of Medicine.[33] Mean MUFA and PUFA intakes were significantly higher in nut consumers compared with non-consumers. This may account for some of the positive effects on cardiovascular health observed in tree nut consumers.[6-8]

Tree nut consumers had higher intakes of all adult shortfall nutrients (fiber; vitamins A, C, and E; calcium; magnesium; and potassium), as identified by the 2005 Dietary Guidelines Advisory Committee[34] when compared to non-consumers. Although the nutrient content of individual tree nuts varies,[2,3,31] most shortfall nutrients, with the exception of vitamin C, are found naturally in tree nuts.[2] Tree nuts are especially rich sources of dietary fiber, vitamin E, and magnesium.[2] For some nutrients, consumption of tree nuts may contribute directly to nutrient intakes as the increase in dietary fiber, vitamin E, and magnesium in adults was 27.2%, 46.7%, and 27.1% higher, respectively, in tree nut consumers as compared to non-consumers. Baseline data from the Nurses' Health study showed that dietary fiber and magnesium intakes were higher in nut consumers than in non-consumers.[11]

Dietary fiber intake is associated with many well known health benefits including improved weight status, serum cholesterol levels, blood pressure, and blood sugar control,[35] as well as lower levels of C-Reactive Protein and higher levels of adiponectin.[5] Dietary fiber also decreases insulin resistance and is inversely associated with the risk of type 2 diabetes.[36] The dietary fiber Dietary Reference Intake (DRI) for males 19-50 years and 51+ years is 38 grams/day and 30 grams/day, respectively, and for females of those ages it is 25 grams/day and 21 grams/day, respectively.[37] Most adults in the US do not meet the daily fiber requirement.[35] In this study, mean fiber intake in the population, even among nut consumers, was below the Adequate Intake level recommended for individuals; however, mean fiber intake among adults in the U.S. was higher than often reported.[35] The fiber intake of tree nut consumers was higher than the fiber content of the nuts in the diet, suggesting that other high fiber foods are contributing to overall intake and that tree nut consumers may have an overall healthier diet than non-consumers.

The contribution of vitamin E that tree nuts provide to the diet is especially important since less than 10% of the population meets the Estimated Average Requirement for vitamin E intake[38] from food alone.[38-40] Epidemiologic evidence suggests that vitamin E is associated with a reduced incidence of all cause and cause-specific mortality.[41] Vitamin E is the most potent antioxidant in plasma, and is associated with reduced risk of heart disease,[42,43] type 2 diabetes,[44] and hypertension.[10,45] It is also associated with reduced oxidative stress[38] and inflammatory markers associated with heart disease[46] and diabetes.[47] Tree nut consumption may be one way to improve vitamin E intake without supplementation while keeping within the recommendations for dietary fat.[48] Almonds are an especially rich source of vitamin E with 26.22 mg/100 gm, followed by hazelnuts with 15.03 mg/100 gm.[2]

Magnesium is an essential cofactor for over 300 metabolic reactions; higher intake is associated with an inverse risk of type 2 diabetes[49] and metabolic syndrome.[50] The relationship between magnesium intake and development of cardiovascular risk factors is less clear;[51] however, an inverse relationship has been demonstrated in some studies.[53] Most Americans do not meet the recommendations for magnesium.[54] On average in this study, tree nut consumers had total dietary magnesium intake levels that were 74 mg/d higher than non-consumers, and mean magnesium intake among tree nut consumers was approximately equal to the DRI of 350 mg/d. Brazil nuts are an excellent source of magnesium providing 376 mg/100 gm, followed by almonds, cashews and pine nuts with 251- 268 mg/100 gm.[2]

Sodium intake was significantly lower in tree-nut consumers than in non-consumers; although both groups exceeded the recommendations.[55] Tree nuts are naturally very low in sodium with an average content of 2 mg/10.5 g. Tree nuts and tree nut butters are usually consumed as snacks or as ingredients in recipes,[20] and thus, may be associated with a high sodium intake. In this study, no effort was made to separate raw or plain roasted tree nuts from salted nuts.

In this study, intake of tree nuts was associated with better overall diet quality as indicated by the higher total HEI-2005 score[28] in consumers, compared to non-consumers. Many of the individual components of the total HEI-2005 score were also higher in consumers, including total and whole fruit, dark green/orange vegetables, legumes, total and whole grains, and SoFAAS, compared with non-consumers. These findings were supported by the improvement in intake in virtually all macro- and micronutrients, except protein, SFA, and vitamin B-12. Epidemiologic studies[20] and small short term feeding studies[56] have also shown that consumption of nuts, including peanuts, improves nutrient intake.

Small percentage increases in mean dietary intake of nutrients among nut consumers compared to non-consumers might be attributable to increased nut consumption, or it may be that tree nut consumption is an indicator of a better diet (*e.g.*, tree nuts are not a source of vitamin C but this nutrient was 13.0 % higher in tree nut consumers as compared to non-consumers). Assessment of MyPyramid food group intake supports the latter possibility by showing that total and whole fruit and dark green/yellow vegetables were increased in tree nut consumers compared to non-consumers.

Limitations

This study had several limitations. NHANES is a cross-sectional study, thus, causal inferences cannot be drawn. Participants relied on their memory to self-report dietary intakes and, therefore, data were subject to non-sampling errors, such as underreporting of energy and examiner effects. It is not known if tree nuts are reported differently than other foods; if they are, there may be an increased risk of misclassifying consumers and non-consumers. Twenty-four hour dietary recalls may not accurately reflect the usual dietary intake patterns of participants; par-

ticularly for an episodically consumed food like tree nuts. Although NHANES began collecting two 24-hour dietary recalls in 2003, and the National Cancer Institute has developed a way to determine usual intake from the two recalls,[57] this was not used since not all individuals in this study had two dietary recalls. In general, with large samples, such as those used in NHANES, 24-hour recalls produce reasonably accurate group estimates of nutrient intake.[58] Lastly, despite a similar nutrient profile, peanuts were not included in the analysis since a recent publication has examined the effect of peanuts on nutrient intake.[20,59]

Conclusions and implications

Consumption of tree nuts in the population was low; however, nutrient intake and diet quality was improved significantly when tree nuts were consumed but mean intakes did not meet most nutrient recommendations. Tree nut consumption should be encouraged by health professionals, including registered dietitians, and nutrition education programs that increase awareness, health benefits, and consumption of tree nuts should be designed. This study also raises the possibility that future dietary recommendations should be specific and perhaps include a separate nut category to encourage consumption.

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Original Article

Tree nut consumption improves nutrient intake and diet quality in US adults: an analysis of National Health and Nutrition Examination Survey (NHANES) 1999-2004

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木本核果攝取改善美國成人營養素攝取及飲食品質：1999-2004 年國家健康及營養調查的分析

近年來很少有關於木本核果(杏仁、巴西核桃、腰果、榛子、澳洲堅果、美洲山核桃、松子、開心果及核桃)的攝取與營養素攝取及飲食品質之間關係的流行病學研究。本篇研究利用全國代表性的成人樣本來確定木本核果的攝取與營養素攝取及飲食品質之間的關係。對象為參與 1999-2004 年國家健康及營養調查(NHANES)之 19 歲以上成人(13,292 名)。飲食的攝取以 24 小時回憶法來決定；有使用木本核果的人定義為每天消耗木本核果 0.25 盎司(7.09 克)及以上者。先經過適當的加權後，計算其平均植、標誤及使用變異數分析(校正共變數)。飲食品質則使用健康飲食指數-2005 來評估。有攝取核果或核果油製品的人，平均攝取量為一天 1.19±0.04 盎司，而被定義為沒有食用的人，平均攝取量為一天 0.01± 0.00 盎司。在本篇研究中，19-50 歲的人(7,049 名)，其中有 5.5±0.3%的人消費核果或核果油製品，而 51 歲以上的人(6,243 名)，消費核果或核果油製品的人則佔了 8.4±0.6%。有攝取核果的人比較沒有攝取核果的人，在一些成人攝取不足的營養素平均差異(p<0.01)為：纖維(+5.0 克/天)，維生素 E(+3.7 毫克 AT/天)，鈣(+73 毫克/天)，鎂(+95 毫克/天)及鉀(+260 毫克/天)。有食用核果的人有較低的鈉攝取(-157 毫克/天, p<0.01)。飲食品質在有消耗核果的人也顯著的較高(58.0±0.4 比 48.5±0.3, p<0.01)。木本核果的攝取與較高的總飲食品質相關，且營養素的攝取方面也較佳。有關核果攝取的特別飲食建議應提供給消費者。

關鍵字：木本核果、營養素攝取、飲食適當性、健康飲食指數-2005、國家健康及營養調查