

Almond Consumption Is Associated with Better Nutrient Intake, Nutrient Adequacy, and Diet Quality in Adults: National Health and Nutrition Examination Survey 2001-2010

Carol E. O'Neil^{1*}, Theresa A. Nicklas², Victor L. Fulgoni III³

¹Louisiana State University Agricultural Center, Baton Rouge, LA, USA

²USDA/ARS Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine, Houston, TX, USA

³Nutrition Impact, LLC, Battle Creek, MI, USA

Email: *coneil1@lsu.edu, tnicklas@bcm.edu, VIC3RD@aol.com

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Abstract

Purpose: The purpose of this study was to examine the association between almond consumption, the most widely consumed tree nut in the US, and nutrient intake, nutrient adequacy, diet quality, and weight/adiposity in adults. **Methods:** Data from adults (N=24,808), 19+ years, participating in the NHANES 2001-2010 were used. The NCI method was used to estimate the usual intake of almonds and selected nutrients. Almond consumers were defined as those consuming any amount of almonds/almond butter. Percentages of the consumers/non-consumers below the Estimated Average Requirement (EAR) or above the Adequate Intake (AI) for select nutrients were determined. To assess significant differences for the percentage of almond consumers vs. non-consumers with intakes less than the EAR or above the AI, a Z-statistic for differences in population proportions was used. Covariate-controlled linear regression was used to determine differences in diet quality, measured by the Healthy Eating Index-2010 (HEI-2010), between the consumer groups. Body mass indices and waist circumference were assessed. P was set at $p < 0.01$. **Results:** Almond consumers were more likely to be non-Hispanic white, older, of higher income, more physically active, and were less likely to be a current smoker than non-consumers. Usual intake of almonds among

*Corresponding author.

consumers was 29.5 ± 1.5 g/day. Usual intake of protein; dietary fiber; vitamins A, D, E, and C; thiamin; niacin; riboflavin; folate, calcium, copper, magnesium, iron, phosphorus, selenium, zinc, and potassium was higher in almond consumers. Almond consumers were less likely to be below the EAR for protein, vitamins A, D, E, B₁₂, and C; riboflavin; calcium; copper; magnesium; iron; phosphorus; and zinc. They were also more likely to be above the AI for dietary fiber and potassium. Total HEI-2010 scores were approximately 15 points higher in almond consumers. Body mass indices and waist circumference measures were lower in almond consumers. Conclusions: Moderate consumption of almonds should be encouraged as part of a healthy diet.

Keywords

Almond Consumption, Tree Nut Consumption, Diet Quality, Nutrients, Nutrient Adequacy, Adults, NHANES

1. Introduction

Almonds (*Prunus dulcis*), a type of tree nut, were one of the first tree nuts to be domesticated [1] and remain an important commercial crop. Native to Central Asia [1], California is now the most important supplier of almonds, producing over 80% of the world crop and virtually 100% of the United States (US) crop [2]. In 2012/2013, nearly 2 billion pounds of almonds were produced [2]. *Per capita* consumption of almonds in the US has increased from approximately 0.84 pounds in 2001/2002 to 1.4 pounds in 2009/2010 to 2 pounds in 2012/2013 [3]. Almonds are versatile, and can be consumed as a snack [4] [5] or as part of a meal—either alone or as part of a prepared dish; almond butter, almond oil, and almond milk can also be prepared from this tree nut.

Almonds are a rich source of nutrients that have been defined by the 2010 Dietary Guidelines for Americans (DGA) as a nutrient-dense food [6]. One serving (1 ounce/28.4 grams [g]) [7] provides 6 g protein (12% of the Daily Value [DV]), 14.2 g total fat (88% unsaturated), 3.5 g dietary fiber (14% DV), 7.27 mg vitamin E (36% DV), 76 mg calcium (8% DV), 136 mg phosphorus (14% DV), and 208 mg potassium (6% DV) [8]. Almonds are also cholesterol and sodium free. According to the United States Department of Agriculture's nutrient data base, one serving of almonds also provides 164 kilocalories (kcal) [8]. However, it has been suggested recently that digestibility of fat from whole nuts (and peanuts, a legume) may be lower than previously thought [9] [10] and that the metabolizable energy content of almonds is actually only 129 kcal/ounce [11]. Almonds also provide phytochemicals including phenolic acids, phytosterols, and polyphenolic compounds such as flavonoids and proanthocyanidins, which have been associated with anti-oxidant and anti-inflammatory properties [12]-[14]. Because of this favorable nutrient/phytochemical profile, almonds are one of the tree nuts eligible for a qualified health claim regarding reducing cardiovascular disease risk [15].

Previous studies have shown that consumption of tree nuts has been associated with positive levels of nutrient intake, including the following short fall nutrients [6] [16]: dietary fiber, vitamin E, calcium, magnesium, and potassium [17] [18]. Tree nut consumers have also been shown to have lower intakes of saturated fatty acids (SFA) and higher intakes of mono-(MUFA) and Poly-Unsaturated Fatty Acids (PUFA) than non-consumers [17] [18]. Tree nut consumers have also been shown to have a better diet quality [17] than non-consumers. Conflicting results regarding the association of tree nut consumption and weight have been shown. Some epidemiologic studies have failed to show an association with weight [17] [19]; whereas, other epidemiologic studies and clinical trials have shown an inverse relationship between Body Mass Index (BMI) and tree nut consumption [20] [21]. Almonds, the most widely consumed nut in the US [3], have not been well studied in these regards; the authors were unable to find any recent epidemiologic studies that looked at the association of almond consumption and nutrient intake or adequacy, diet quality, or weight status. Long-term feeding studies have shown that almond consumers have higher intakes of vegetable protein, dietary fiber, MUFA, PUFA, α -tocopherol, copper, and magnesium [22] and that long-term consumption of almonds was not adversely associated with BMI [23]-[26]. The purpose of this study was to determine whether there was an association between almond consumption and nutrient intake, nutrient adequacy, diet quality, and using a nationally representative sample of US adults.

2. Subjects and Methods

2.1. Study Population and Analytic Sample

For these analyses, data from adults 19+ years of age (y) and older (N = 24,808) participating in the National Health and Nutrition Examination Survey (NHANES) 2001-2010 were concatenated to increase sample size [27] [28]. Analyses included only individuals with dietary recalls determined to be reliable by the National Center for Health Statistics (excluded n = 147); females who were pregnant or lactating (n = 1128) were also excluded from the analyses. The NHANES has strict procedures that guarantee confidentiality and protect individual participants from identification [29]; Institutional Review Board review was not required [30].

2.2. Demographics and Dietary Information

Demographic information was obtained from the NHANES interview administered in the home [31]. Demographic information obtained from the questionnaire included gender, race/ethnicity, age, physical activity, current smoking status, and the poverty income ratio (PIR). The PIR is the ratio of family income to poverty, and was calculated by dividing individual or family income by the United States poverty guidelines specific to the survey year. The lowest value indicates individuals or families below the poverty line. This demographic information, along with alcohol intake, obtained through the 24-hour dietary recalls described below, served as covariates for the statistical analyses.

Dietary data were collected using two 24-hour dietary recalls using an automated multiple-pass method [32] [33]; the first recall was conducted in person by a trained interviewer in the Mobile Examination Center [34] and the second recall was conducted 3 - 10 days later via telephone [35]. Detailed descriptions of the dietary recalls and data collection are available in the NHANES Dietary Interviewer's Training Manual [36].

The USDA Food and Nutrient Database for Dietary Studies (FNDDS) [37] food codes for almond/almond butter (together referred to as "almonds" in this manuscript) were used to identify almond consumers: 42100100, 42101000, 42101100, 42101200, 42101210, 42101350, 42200500, and 42200600. Individuals were classified as almond consumers if any amount of almonds was ingested on either day of the recall. For each participant, daily total nutrient intakes from foods and beverages were obtained from the total nutrient intake files associated with each FNDDS data release. The Vitamin D Addendum to USDA FNDDS 3.0 [38] was used to determine vitamin D intake. Intake from supplements was not considered.

2.3. Diet Quality as Determined by the Healthy Eating Index (HEI-2010)

The HEI-2010 was used to determine diet quality [39] [40]. The SAS code used to calculate HEI-2010 scores was downloaded from the Center for Nutrition Policy and Promotion website [41]. Briefly, HEI-2010 was designed to evaluate all of the major food groups and major subgroups and nutrients to manage in the diet. The twelve HEI-2010 components were summed for a maximum score of 100 points. Components 10 (sodium), 11 (refined grains), and 12 (empty calories) are reverse scored, so the higher the score, the lower intake and the greater the contribution to diet quality.

2.4. Anthropometric Measures

Height, weight, and waist circumference (WC) were obtained according to NHANES protocols [42]. Body Mass Index (BMI) was calculated as body weight (kilogram) divided by height (meters) squared.

2.5. Statistical Analyses

Sampling weights and the sampling units and strata information, as provided by NHANES, were included in all analyses using SUDAAN v10.0 (Research Triangle Institute; Raleigh, NC) [27] [28]. Linear regression was used to determine differences between almond consumers and non-consumers for energy, macronutrients, HEI-2010, HEI-2010 subcomponents, and weight parameters. Least-square means and standard errors were calculated using PROC REGRESS of SUDAAN. For these analyses, most covariates were obtained from the questionnaire (or in the case of alcohol consumption the 24 hour dietary recalls), and were age, gender, ethnicity, poverty index ratio (one of three levels: 0 - 1.25, 1.25 - 3.5, >3.5) [31]; physical activity level (sedentary, moderate, or vigorous) [43], current smoking status, and alcohol consumption, which was obtained from the 24-hour dietary recall. For intake of total nutrients, total energy intake was also included as a covariate.

Usual intake (UI) determinations represent long term average daily intakes and were determined by removing excessive intra-person variation in intakes; these are the best estimates to compare to dietary recommendations as suggested intakes are to be met over time, rather than measured on a single day. Usual intake of almond consumption and selected nutrients was determined using the National Cancer Institute (NCI) method [44]. Usual intakes were determined using SAS v 9.2 (SAS Institute, Cary, NC). For UI of almonds, which are consumed episodically, the two part NCI model (probability and amount) was used; for nutrients which are consumed daily by most people, the one part model was used. The NCI SAS macros (Mixtran v1.1 and Distrib v1.1) were used to generate parameter effects after covariate adjustments and to estimate the distribution of UI via Monte Carlo simulation methods, respectively [44]. Covariates in this study were day of the week of the 24-hr recall [coded as weekend (Friday-Sunday) or weekday (Monday-Thursday)] and sequence of dietary recall (first or second). Software provided by NCI was used with the two days of intake using one-day sampling weights to obtain appropriate variance estimates. Balanced repeated replication (BRR) was performed to obtain standard errors and confidence intervals for the percentiles; BRR weights were constructed with Fay adjustment factor $M = 0.3$ (perturbation factor 0.7) and further adjusted to match the initial sample weight totals within specific age/gender/ethnicity groupings for the full dataset. The Dietary Reference Intake (DRI) age groups were used to present UI for each nutrient studied.

To assess the extent of inadequate intake of nutrients with an Estimated Average Requirements (EAR), the cut-point method proposed by the Institute of Medicine [45] was used. The EAR is the appropriate DRI to use when assessing the adequacy of group intakes [45] [46]. The EAR cut-point method provides an estimate of the proportion of individuals in the group with inadequate intakes by age and gender. For nutrients without an EAR, *i.e.* dietary fiber, sodium, and potassium, the percent above the Adequate Intake (AI) was determined. To determine if there were significant differences for the percentage of almond consumers vs. non-consumers with intakes less than the EAR or above the AI a Z-statistic for differences in population proportions was used. A $p < 0.01$ was considered significant.

3. Results

3.1. Demographics and Almond Consumption

Subjects were adults 19+ y ($N = 24,808$; 49% female) participating in the NHANES 2001-2010. Almond consumers were more likely ($p < 0.01$) to be non-Hispanic white, older, of higher income, more physically active, and were less likely to be a current smoker than non-consumers (Table 1). Approximately 1.6% of the population was almond consumers. *Per capita* consumption was 0.6 ± 0.03 g/day (d) (0.148 ounces/week) and consumption in almond consumers was 29.5 ± 1.5 g/d (7.284 ounces/week).

Table 1. Demographics of adults 19+ years ($N = 24,808$) participating in NHANES 2001-2010 by almond consumption.

Variable	Consumers (n = 395) LSM \pm SE	Non-Consumers (n = 24,413) LSM \pm SE	P-Value
Gender (%)			
Female	62.53 \pm 2.91	50.61 \pm 0.34	<0.0001
Ethnicity (%)			
Non-Hispanic White	84.28 \pm 2.03	71.12 \pm 1.45	<0.0001
Non-Hispanic Black	3.68 \pm 1.01	11.47 \pm 0.78	<0.0001
Mexican-American	4.89 \pm 0.94	7.90 \pm 0.72	0.0113
Age (Years)	51.59 \pm 1.01	46.36 \pm 0.25	<0.0001
Poverty Income Ratio	3.96 \pm 0.10	2.99 \pm 0.03	<0.0001
Physical Activity (%)			
Sedentary	12.08 \pm 1.94	29.33 \pm 0.60	<0.0001
Moderate	34.54 \pm 2.98	34.09 \pm 0.48	0.8836
Active	53.38 \pm 3.22	36.58 \pm 0.73	<0.0001
Smoker, current (%)	8.54 \pm 1.96	24.58 \pm 0.56	<0.0001
Alcohol (g)	10.48 \pm 1.37	11.04 \pm 0.33	0.6919

3.2. Intake of Protein, Dietary Fiber, and Selected Micronutrients

Almond consumers had higher ($p < 0.01$) intakes of protein, dietary fiber, total fat, MUFA, and polyunsaturated fatty acids (PUFA) than non-consumers (Table 2). Almond consumers also had lower ($p < 0.01$) intakes of total and added sugars and SFA than non-consumers (Table 2). Usual intake of vitamins A, D, E, and C; riboflavin; folate, calcium, copper, magnesium, iron, and phosphorus were all higher ($p < 0.01$) in almond consumers compared with non-consumers (Table 3). Table 4 shows that UI of dietary fiber and potassium were higher ($p < 0.01$) in almond consumers compared with non-consumers.

3.3. Nutrient Adequacy

Table 4 shows that almond consumers were less likely ($p < 0.01$) to be below the EAR for protein, vitamins A, E, and C; riboflavin; calcium; copper; magnesium; phosphorus; and zinc. Almond consumers were also more likely ($p < 0.01$) to be above the AI for dietary fiber (Table 4) than non-consumers.

3.4. Diet Quality

Total HEI-2010 scores were approximately 15 points higher in almond consumers (62.46 ± 0.86) than in non-consumers (46.61 ± 0.22) ($p < 0.01$) (Table 5). In almond consumers, higher ($p < 0.01$) component scores were seen for every individual component of the HEI-2010, except dairy, when compared with non-consumers. It should be noted that component scores 10 (sodium), 11 (refined grains), and 12 (empty calories) are reverse scored, that is the higher the score, the greater the contribution to diet quality.

3.5. Anthropometric Measures

Body mass index was significantly lower ($p < 0.01$) in almond consumers (27.1 ± 0.34 v 28.4 ± 0.08) than in non-consumers, respectively. Waist circumference was also significantly lower ($p < 0.01$) in almond consumers (94.1 ± 0.9 v 97.5 ± 0.2 cm) than in non-consumers, respectively.

4. Discussion

This is the only published epidemiologic study showing the association between nutrient intake, diet quality, and weight/adiposity parameters in almond consumers that we were able to find. Almond consumption was associated with better nutrient intake, dietary adequacy, and diet quality than seen in non-consumers. Weight and adiposity measures were also lower in almond consumers.

Table 2. Least-square mean macronutrient nutrient intake \pm SE in adults 19+ years participating in NHANES 2001-2010 by almond consumption status.

Variable ^{1,2}	Consumers LSM \pm SE	Non-Consumers LSM \pm SE	P-Value
Energy (kcal)	2286.7 \pm 51.8	2176.0 \pm 9.4	0.0414
Protein (gm)	91.3 \pm 1.7	83.0 \pm 0.3	<0.0001
Total sugars (gm)	113.1 \pm 3.8	123.3 \pm 0.8	0.0081
Added sugars (tsp eq)	14.5 \pm 0.8	19.2 \pm 0.2	<0.0001
Dietary fiber (gm)	22.1 \pm 0.7	15.9 \pm 0.1	<0.0001
Total fat (gm)	87.6 \pm 1.8	82.2 \pm 0.3	0.0042
SFA (gm)	24.2 \pm 0.8	27.1 \pm 0.1	0.0005
MUFA (gm)	35.1 \pm 0.6	30.2 \pm 0.1	<0.0001
PUFA (gm)	20.8 \pm 0.9	17.4 \pm 0.1	<0.0001
Cholesterol (mg)	284.5 \pm 16.4	287.4 \pm 2.1	0.8604

Data Source: Participants 19 years and older of the NHANES 2003-2010. ¹Covariates for energy: ethnicity, age, poverty income ratio, physical activity, smoker status, alcohol. ²Covariates for nutrients: ethnicity, age, poverty income ratio, physical activity, smoker status, alcohol, and energy (kcal). Abbreviations: SFA = saturated fatty acids; MUFA = mono-unsaturated fatty acids; PUFA = poly-unsaturated fatty acids.

Table 3. Usual intake¹ and estimated average intake of protein and selected micronutrient among adult consumers (n = 395) and non-consumers (n = 24,414) of Almonds.

Variable	Almond Consumption Group	Usual Intake		Percentile					EAR	
		Mean ± SE	P	10	25	50	75	90	% Below ± SE	P
Protein (gm)	Consumer	92.3 ± 2.6	0.0002	56.4	68.3	86.1	110.6	136.5	0.6 ± 0.4	0.0058
	Non-Consumer	82.5 ± 0.4		51.1	62.7	78.7	98.9	119.6	2.0 ± 0.2	
Vitamin A, RAE (mcg)	Consumer	803.1 ± 35.2	<0.0001	472.6	594.0	759.1	963.1	1183.8	17.9 ± 4.7	<0.0001
	Non-Consumer	606.9 ± 6.4		291.2	401.6	558.7	759.6	983.4	49.8 ± 0.9	
Vitamin D ² (mcg)	Consumer	6.1 ± 0.6	0.0065	2.5	3.8	5.5	7.7	10.3	88.9 ± 4.7	0.1544
	Non-Consumer	4.6 ± 0.1		1.7	2.6	4.0	5.9	8.1	95.6 ± 0.3	
Vitamin E ³ (mg)	Consumer	17.0 ± 0.9	<0.0001	9.6	12.3	16.1	20.8	25.6	23.3 ± 5.2	<0.0001
	Non-Consumer	7.2 ± 0.1		4.1	5.2	6.8	8.8	10.9	94.1 ± 0.4	
Thiamin (mg)	Consumer	1.8 ± 0.1	0.0482	1.0	1.3	1.7	2.2	2.7	7.4 ± 2.1	0.5860
	Non-Consumer	1.7 ± 0.01		1.0	1.2	1.6	2.0	2.4	6.3 ± 0.4	
Niacin (mg)	Consumer	26.7 ± 0.9	0.0339	15.6	19.5	25.2	32.5	39.8	1.3 ± 0.9	0.5718
	Non-Consumer	24.8 ± 0.2		14.9	18.5	23.5	29.9	36.5	1.8 ± 0.3	
Riboflavin (mg)	Consumer	2.6 ± 0.1	<0.0001	1.6	2.0	2.6	3.2	3.7	0.1 ± 0.1	<0.0001
	Non-Consumer	2.2 ± 0.01		1.3	1.6	2.1	2.7	3.3	2.4 ± 0.2	
Folate, DFE (mcg)	Consumer	603.9 ± 20.7	0.0053	336.1	430.6	563.5	732.7	923.5	7.9 ± 7.6	0.6431
	Non-Consumer	544.9 ± 4.5		309.7	395.2	513.4	660.5	820.6	11.5 ± 0.5	
Vitamin B ₁₂ (mcg)	Consumer	5.8 ± 0.3	0.0847	2.9	3.8	5.2	7.2	9.4	2.7 ± 1.4	0.5218
	Non-Consumer	5.2 ± 0.1		2.6	3.5	4.8	6.5	8.4	3.6 ± 0.3	
Vitamin C (mg)	Consumer	109.8 ± 4.9	<0.0001	49.1	70.6	101.1	139.3	181.3	20.1 ± 3.8	<0.0001
	Non-Consumer	86.3 ± 1.1		31.8	48.7	74.9	111.3	154.9	42.6 ± 1.0	
Calcium (mg)	Consumer	1126.3 ± 41.8	<0.0001	705.6	874.6	1093.2	1340.7	1590.7	27.4 ± 3.5	<0.0001
	Non-Consumer	922.8 ± 6.2		503.6	655.3	865.3	1126.9	1415.3	47.9 ± 0.7	
Copper (mg)	Consumer	1.9 ± 0.1	<0.0001	1.1	1.4	1.8	2.2	2.7	0.4 ± 0.2	<0.0001
	Non-Consumer	1.3 ± 0.01		0.8	1.0	1.2	1.6	1.9	4.7 ± 0.4	
Magnesium (mg)	Consumer	427.3 ± 13.7	<0.0001	270.7	331.4	412.9	507.7	602.2	11.3 ± 2.2	<0.0001
	Non-Consumer	289.5 ± 2.0		176.7	219.5	276.7	345.9	418.9	60.8 ± 0.9	
Iron (mg)	Consumer	17.8 ± 0.6	<0.0001	10.3	12.9	16.6	21.4	26.84	6.6 ± 1.01	0.1262
	Non-Consumer	15.6 ± 0.1		9.3	11.6	14.8	18.7	22.93	8.2 ± 0.3	
Phosphorus (mg)	Consumer	1584.7 ± 65.6	0.0003	1003.7	1207.2	1492.6	1870.9	2294.4	0.1 ± 0.1	<0.0001
	Non-Consumer	1347.9 ± 6.7		829.1	1025.4	1288.5	1610.8	1949.4	1.3 ± 0.2	
Selenium (mcg)	Consumer	116.4 ± 4.1	0.1170	63.9	82.5	111.8	146.0	174.7	1.5 ± 0.7	0.2141
	Non-Consumer	110.0 ± 0.6		68.2	83.6	104.9	131.5	159.0	0.7 ± 0.1	
Zinc (mg)	Consumer	13.1 ± 0.6	0.0980	8.0	9.7	12.2	15.6	19.4	5.4 ± 2.2	0.0012
	Non-Consumer	12.1 ± 0.1		7.1	8.9	11.4	14.5	18.0	12.8 ± 0.6	

Data Source: Participants 19 years and older of the NHANES 2003-2010. Covariates: ethnicity, age, poverty income ratio, physical activity, smoker status, alcohol, and energy (kcal). Abbreviations: EAR = Estimated Average Requirement; AI = Adequate Intake; RAE = retinol activity equivalents; DFE = dietary folate equivalent. ¹Excludes Supplement Use; ²Vitamin D (D2 + D3) (mcg); ³Vitamin E as α -tocopherol (mg).

Table 4. Usual intake¹ and adequate intake of protein and selected micronutrient among adult consumers (n = 395) and non-consumers (n = 24,414) of almonds.

Variable	Almond Consumption Group	Usual Intake		Percentile					AI	
		Mean ± SE	P	10	25	50	75	90	% Above ± SE	P
Dietary fiber (gm)	Consumer	23.7 ± 0.8	<0.0001	14.5	17.9	22.8	28.6	35.0	33.7 ± 4.3	<0.0001
	Non-Consumer	15.9 ± 0.1		8.9	11.6	15.1	19.3	23.8	4.0 ± 0.3	
Sodium (mg)	Consumer	3401.1 ± 100.0	0.1848	2218.7	2675.6	3389.8	4170.9	4822.4	99.9 ± 0.2	0.2992
	Non-Consumer	3626.6 ± 17.6		2249.6	2755.6	3448.9	4308.3	5201.4	99.6 ± 0.1	
Potassium (mg)	Consumer	3271.5 ± 86.4	<0.0001	2154.5	2610.1	3210.8	3901.6	4610.0	8.7 ± 2.6	0.0125
	Non-Consumer	2715.4 ± 15.5		1675.3	2080.4	2606.8	3227.6	3868.0	2.4 ± 0.2	
Total Choline	Consumer	342.9 ± 13.6	0.2981	209.7	261.3	342.3	421.7	483.7	6.6 ± 3.2	0.8998
	Non-Consumer	333.4 ± 1.9		197.3	244.4	311.1	397.7	490.3	6.2 ± 0.4	

Data Source: Participants 19 years and older of the NHANES 2003-2010. Covariates: ethnicity, age, poverty income ratio, physical activity, smoker status, alcohol, and energy (kcal). Abbreviations: AI = Adequate Intake. ¹Excludes Supplement Use.

Table 5. Mean total Healthy Eating Index-2010 (HEI) and component scores ± SE in adults 19+ years participating in NHANES 2001-2010 by almond consumption category.

Variable	Consumers	Non-Consumers	P
	LSM ± SE	LSM ± SE	
HEI-2010 Total Score	62.5 ± 0.9	46.6 ± 0.2	<0.0001
Component 1 (Total Vegetables)	3.4 ± 0.1	3.1 ± 0.02	<0.0001
Component 2 (Greens and Beans)	1.7 ± 0.2	1.1 ± 0.02	0.0003
Component 3 (Total Fruit)	3.0 ± 0.1	2.2 ± 0.03	<0.0001
Component 4 (Whole Fruit)	3.0 ± 0.2	2.0 ± 0.03	<0.0001
Component 5 (Whole Grains)	2.9 ± 0.2	2.1 ± 0.04	0.0026
Component 6 (Dairy)	5.4 ± 0.2	4.9 ± 0.1	0.0473
Component 7 (Total Protein Foods)	4.7 ± 0.1	4.1 ± 0.02	<0.0001
Component 8 (Seafood and Plant Protein)	4.3 ± 0.1	1.9 ± 0.02	<0.0001
Component 9 (Fatty Acid Ratio)	7.4 ± 0.2	4.8 ± 0.04	<0.0001
Component 10 (Sodium)	5.0 ± 0.3	4.2 ± 0.04	0.0039
Component 11 (Refined Grains)	7.5 ± 0.2	5.9 ± 0.1	<0.0001
Component 12 (Empty Calories)	14.2 ± 0.4	10.3 ± 0.1	<0.0001

Covariates: Gender, ethnicity, age, poverty income ratio (PIR 0 - 1.25, 1.25 - 3.5, ≥3.50), physical activity level (sedentary, moderate, active), current smoking status.

According to the Economic Research Service of the USDA [3], almonds have the highest *per capita* utilization of the tree nuts. This study showed that only approximately 1.6% of the study population consumed almonds; however, this percentage still represents over 2 million individuals. On average, almond consumers easily met the DGA recommendation for nuts and seeds of 2 to 8 ounces of total nuts per week [6]. Further studies are needed to determine the extent to which the population on the whole is meeting this recommendation.

Consumption of almonds was associated with higher intake of several nutrients of public health concern [6], including dietary fiber, calcium, and potassium, as well as higher intakes of shortfall nutrients including vitamins A, E, and C; folate; iron and magnesium [18]. These findings are similar to those seen with other tree nuts

[17]. A limitation of cross-sectional studies, like the NHANES, is that they cannot show a causal association and there is a possibility that since 24-hour dietary recalls are memory dependent, individuals may be spuriously placed in a consumption group. However, Jaceldo-Siegl *et al.* [22] [26] showed that in a long term feeding trial with almonds, nutrient intake of short-fall and some nutrients to limit also improved.

This study expanded previous epidemiologic studies of tree nuts in which it used UI to determine nutrient adequacy rather than simply nutrient intake and concentrated on the most widely consumed tree nut. The EAR is the appropriate value when assessing groups or individuals; however, the AI is not as effective when assessing nutrient adequacy, since it is used when an EAR is not available [45] [46]. This study showed that almond consumers were less likely to be below the EAR for some nutrients and above the AI for others than non-consumers. In this study, mean dietary fiber intake in the population, even among almond consumers, was below the AI level recommended for individuals; however, mean fiber intake among adults in the U.S. was higher than that often reported by US adults [47] [48]. The fiber intake of almond consumers was higher than the fiber content found in the mean amount of almonds consumed, suggesting that other high fiber foods are contributing to overall intake and that almond consumers may have an overall healthier diet than non-consumers. The HEI-2010 component scores suggest that almond consumers had higher intakes of high fiber foods, such as fruit, vegetables, beans and whole grains.

Of particular import is the high intake and better nutrient adequacy for Vitamin E, for which there is a paucity of food sources, seen in almond consumers. The 2005 Dietary Guidelines Advisory Committee (DGAC) [49] identified vitamin E as a shortfall nutrient, whereas the 2010 DGAC did not [50], in part because the role of vitamin E and health was not well established [51]-[53]. The 2010 DGA did find that oil intake fell short of recommended intakes and that vitamin E was an important nutrient in oils. Vitamin E is a potent antioxidant with lipoperoxyl radical-scavenging activities [51]-[53]. Most Americans do not consume the recommended amounts of vitamin E [6]. A recent meta-analysis has shown that vitamin E intake alone or combined with other agents reduced all-cause mortality, but low doses of vitamin E combined with other agents may be more efficacious [52].

Diet quality, as measured by HEI-2010, was approximately 15% higher in almond consumers compared to non-consumers. Almost all component scores of the HEI-2010 were better in almond consumers. Especially notable were seafood and plant protein (component 8), fatty acid ratio (component 9), and empty calories (component 12). Seafood, nuts and seeds, and soy products (except soy milk) are counted in component 8 [39] [40]. This component has a maximum score of 5 and almond consumers score nearly 4.5. The fatty acid ratio is the ratio of PUFA and MUFA to SFA, and reflects the DGA recommendation to replace SFA with MUFA and PUFA [6]. The maximum score for this component is 10. Almonds have a very favorable lipid profile: a one ounce serving of almonds contains 12.44 g of unsaturated fatty acids, compared with only 1.02 g of SFA. Empty calories are defined as those kilocalories from solid fats, alcohol (threshold >13 g/1000 kcals), and added sugars; and the maximum score is 20 ($\leq 19\%$ of energy) [39]; almond consumers have a score of 14.15. Other component scores of the HEI-2010, which were also higher in almond consumers, such as total vegetables, greens and beans, and total/whole fruit, are not directly linked with almonds, suggesting that almond consumers may have a healthier diet than non-consumers. The demographic data also suggest that almond consumers may have an overall healthier lifestyle with a higher percentage of physical activity and a lower percentage of smoking. Recently, it is suggested that nut consumers, in general, have a healthier lifestyle than non-consumers [54]; however, this has not been shown for almond consumers.

There has been hesitancy about recommending the inclusion of almonds (and other tree nuts) in the diet because it has been speculated that their high energy and fat content could cause weight gain [55]; although more recent studies have suggested that the energy content of almonds is less than previously thought [11]. Since NHANES is a cross-sectional study, weight gain cannot be determined; however, almond consumers had lower mean BMI and WC values than non-consumers. Although some epidemiologic studies have shown higher energy intake among tree nut consumers [17], although this study did not, the same studies have also shown an inverse relationship with weight parameters [17] [19]; other studies have shown that the participants were at lower risk for obesity [56]. Potential reasons for this are the proposed usable energy content [11], high satiety value that almonds provide, coupled with energy compensation [25], and raising resting energy metabolism [25]. Similar epidemiologic studies have not been conducted in almond consumers; however, long term intervention studies have shown that almond consumption was not associated with lower weights or with weight gain [4] [5] [26]. Another study showed that, although those consuming an almond-enriched hypoenergetic diet lost weight,

they did not lose as much weight as those consuming a nut-free hypoenergetic diet [23]. Thus, additional studies evaluating weight and almond consumption are needed.

The strengths of this study are that it used a large, nationally representative population. In addition, UI was calculated so that nutrient adequacy, in addition to nutrient intake, could be determined. The limitations of this study are that NHANES is a cross-sectional study; thus, causal inferences cannot be drawn. Twenty-hour dietary recalls have several inherent limitations: they are memory dependent and subjects may over- or under-report energy intake. Further, while we adjusted for numerous covariates, differences described might be due to residual confounding. Lastly, there is a possibility that almond consumers were misclassified.

In conclusion, consumption of almonds was associated with nutrient intake, nutrient adequacy, better diet quality, and better weight parameters than those seen in non-consumers. It is likely that almonds contributed to these results and to an overall healthy diet. Thus, consumption of almonds should be included as part of a healthy diet.

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