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Chickpeas and Hummus are associated with Better Nutrient Intake, Diet Quality, and Levels of Some Cardiovascular Risk Factors: National Health and Nutrition Examination Survey 2003-2010

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Abstract

Background: Epidemiologic studies assessing chickpea/hummus consumption and the association with nutrient intake, diet quality, and health biomarkers are lacking.

Methods: The association between chickpea/hummus consumption and nutrient intake, dietary quality, and health biomarkers was examined in adults using data from NHANES 2003-2010. Consumers (n=264) were defined as having consumed any amount of chickpeas/hummus during either of the two 24-hour diet recalls.Means and ANOVA (covariate adjusted) were determined using appropriate sample weights; significance was p<0.01. Diet quality was calculated using the Healthy Eating Index-2005 (HEI). Covariate adjusted odds ratios were calculated to determine the likelihood that consumption of chickpeas/hummus was associated with a lower risk of physiologic outcomes.

Results: Dietary fiber (24.4 ± 0.7 v 10.1 ± 0.1 g/d); polyunsaturated fatty acids (19.5 ± 0.4 v 17.3 ± 0.1 g/d); vitamins A (787 ± 42 v 640 ± 6 RAE mcg/d), E (10.1 ± 0.5 v 7.5 ± 1.01 mcg/d), and C (119 ± 8 v 86.4 ± 4.3 mg/d); folate (627 ± 16 v 547 ± 4 mcg/d);magnesium (385 ± 13 v 292 ± 4 mg/d); potassium 3103 ± 59 v 2697 ± 12 mg/d); and iron (17.4 ± 0.5 v 15.8 ± 0.1 mg/d) intake was higher in consumers. Total fat (76.4 ± 4.5 v 80.4 ± 0.3 g/d), saturated fatty acids (SFA) (22.4 ± 0.7 v 26.6 ± 0.1 g/d), and cholesterol (227 ± 8 v 288 ± 2 mg/d) were lower in chickpea/hummusconsumers. Chickpea/hummus consumers had higher HEI-2005 scores (62.2 ± 1.3 v 51.9 ± 0.2). Body Mass Index (26.4 ± 0.5 v 28.6 ± 0.1) and waist circumference (92.2 ± 1.3 v 97.9 ± 0.3 cm) were lower in consumers. As compared to non-consumers, adult hummus/garbanzo bean consumers were 53% less likely to be obese, 43% less likely to be overweight or obese; a 48% reduced risk of increase WC, and 51% less likely to have an elevated glucose level.

Conclusion: Chickpea/hummus consumption was associated with better nutrient intake, diet quality and weight parameters in adults, and consumption should be encouraged.

Keywords: Chickpeas; Garbanzo beans; Hummus; Legumes; NHANES; Nutritional epidemiology; Nutrient intake; Cardiovascular risk factors

Abbreviations: BMI: Body Mass Index; CVRF: Cardiovascular Risk Factors; DBP: Diastolic Blood Pressure; HDL-C: High-density lipoprotein-cholesterol; HEI-2005: Healthy Eating Index-2005; HOMA-IR: Homeostatic Model Assessment—Insulin Resistance; LDL-C: Low-density lipoprotein-cholesterol; NHANES: National Health and Nutrition Examination Survey; OR: Odds Ratio; PUFA: Polyunsaturated Fatty Acids; SBP: Systolic Blood Pressure; SFA: Saturated Fatty Acids; USDA: United States Department of Agriculture; WC: Waist Circumference

Introduction

Chickpeas (*Cicerarietinum* L.) also known as chickpeas, cici, Bengal gram or garbanzo beans, are an old world pulse first grown in the Levant and ancient Egypt [1]. The two main varieties of chickpeas are the large, light-seeded Kabuli type and the smaller, dark Desi type [2]. From a culinary standpoint, chickpeas have a nut-like flavor and are very versatile; they can be served in salads or cooked into stews; they can also complement grains to form a source of complete proteins for vegetarians or low socio-economic individuals. Increasingly popular in the US is hummus, a dip/spread that is made with pureed chickpeas and other healthful ingredients including tahini, olive oil, lemon juice, and garlic.

Chickpeas are an important food crop, especially in India, the Middle East, and Africa. Worldwide, in 2011, the global chickpea area harvested was over 13 million hectares, with a production of approximately 10.5 metric tons [3]. In the US, production of dried chickpeas has increased sharply over the past several years. The percent change in dried chickpea production from 2010 to 2011 was second highest among legumes with only pinto beans showing a larger change. The production of total chickpeas went from 2,202 (hundred weight [cwt]) 2011 to (3,322 cwt) in 2012 [4]. It is, however, difficult to determine per capita availability since the USDA's Economic Research Service does not consideravailability of dried chick peas separately; however, since production in the US is increasing, it is logical to assume

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that consumption is also increasing, although consumption of all dried beans is low [5].

It has been speculated that there is a growing demand for chickpeas because of their unique nutrient profile [6-8]. Dried chickpeas are a rich source of plant protein [8,9]; dietary fiber [6,8]; resistant starch [10,11]; vitamins and minerals [8], especially folate, calcium, magnesium, phosphorus, and potassium; and phytochemicals, including sterols, phytoestrogens, carotenoids, and isoflavones [6,12-14]. Chickpeas are also relatively high in polyunsaturated fatty acids (PUFA) [8]; however, levels are not high enough for to classify them as an oilseed. Canned chickpeas have a similar nutrient profile to cooked dried chickpeas; however, they are higher in sodium [8]. Chickpeas also have anti-nutritional factors, including protease inhibitors, alkaloids, tannins, phytic acid, and saponins [6]. These can reduce the digestibility of chickpeas and make chickpeas astringent. Phytates can also bind to cations, including iron, zinc, calcium, and magnesium, limiting their absorption [6]. The effect of these anti-nutritional factors can be reduced by cooking [15]; however, they have also been associated with several health benefits, including potentially lowering the risk of chronic disease [6]. Commercially available hummus provides dietary fiber, folate, calcium, magnesium, phosphorus, potassium, and, unsaturated oils [8].

Small clinical trials have shown conflicting results when chickpeas were added to a typical Australian diet. Both studies showed increased intake of dietary fiber and decreased intake of saturated fatty acids (SFA) [7,10]; however, one showed an increase in PUFA intake [7], while another showed a decrease [10]. Nestle et al. [10] also showed decreased consumption of cholesterol in consumers.

Health benefits of consuming legumes, including chickpeas and recipes made from chickpeas such as hummus, including potentially reducing the risk of developing chronic diet related diseases, including obesity, cardiovascular diseases, and type 2 diabetes have also contributed to their growing popularity. Pulses, including chickpeas, have a nutrient profile consistent with weight control and anti-nutrients, which constitute part of the composition of pulses, are also thought to assist in weight control [16,17]. Consumption of chickpea supplemented diets has been associated with lower total serum cholesterol and low-density lipoprotein cholesterol (LDL-C) levels [7,18,19], as well as lower levels of insulin and homeostatic model assessment—insulin resistance (HOMA-IR) [7,10]. Other health benefits related to blood glucose control have been assumed due to the level of resistant starch in chickpeas/hummus and the low glycemic index of chickpeas [6].

There are no published cross-sectional studies that have looked at chickpea/hummus consumption and a potential association with better nutrient intake, diet quality, and cardiovascular risk factors (CVRF). The purpose of this study was to determine whether there was an association between chickpea/hummus consumption and nutrient intake, diet quality, and CVRF using a nationally representative sample.

Materials and Methods

Study population and analytic sample

For these analyses, data from adults 19+ years of age (y) and older (N=17,873) participating in the NHANES 2003-2010were merged to increase sample size [20,21]. Analyses included only individuals with dietary records judged to be reliable by the National Center for Health Statistics staff; females who were pregnant or lactating were excluded from the analyses. The NHANES has stringent protocols and procedures that ensure confidentiality and protect individual participants from identification using federal laws [22]. By definition, this study did not have human subjects; therefore, no additional Institutional Review Board approval was needed [23].

Demographics and Dietary Information

Demographic information was determined from the NHANES interview administered in the Mobile Examination Center [24]. Intake data were obtained from What We Eat in America which collected an in-person 24-hour dietary recall interview and a telephone 24-hour dietary recall conducted three to ten days later. Both types of recalls were administered using an automated multiple-pass method [25,26]. Detailed descriptions of the dietary interview methods are provided in the NHANES Dietary Interviewers Procedure Manuals [27,28].

Chickpea/hummus intake was determined by using USDA Standard Reference [8] information identifying the food codes which were at least 75% chickpea/hummus by weight after adjusting for water content. Intakes used in the analyses are the 2-day average intakes. The USDA Food and Nutrient Database for Dietary Studies [8] food codes used to identify chickpea consumers were 41302000, 41302010, and 41302020; the food code for hummus was 41205070.Individuals were classified as consumers if any amount chickpeas or hummus were ingested either day of the recall. For each participant, daily total energy and nutrient intakes from foods and beverages were obtained from the total nutrient intake files associated with each data release. The Vitamin D Addendum to USDA Food and Nutrient Database for Dietary Studies 3.0 [29] was used to determine vitamin D intake. Intake from supplements was not considered.

Diet Quality as determined by the Healthy Eating Index (HEI-2005)

The HEI-2005 was used to determine diet quality [30]. The SAS code used to calculate HEI-2005 scores was downloaded from the Center for Nutrition Policy and Promotion website [31].

Anthropometric and Physiologic Measures

Standard NHANES protocols were used to determine height, weight, and waist circumference (WC) [32]. Body mass index (BMI) was calculated as body weight (kilograms) divided by height (meters) squared [33]. Overweight/obesity and WC were defined using the National Heart Lung and Blood Institute Clinical Guidelines [33]; overweight was defined as a BMI between 25 and 29.9, whereas obesity was defined as a BMI $\geq$30. High waist WC was defined as >102 cm (males) or>88 cm (females).Systolic (SBP) and diastolic blood pressures (DBP) were determined using the standard NHANES protocol [34]. HOMA-IR was calculated using insulin x glucose (mg/dL)/405. Total and high density lipoprotein-cholesterol (HDL-C) were determined on non-fasted individuals [35] while LDL-C [35], triglycerides [35], blood glucose [36], and insulin [36] were determined on only fasted subjects; thus, not all individuals had laboratory values for all tests.

Metabolic syndrome was defined using the National Heart Lung and Blood Institute Adult Treatment Panel III criteria [37]; that is having 3 or more of the following risk factors: abdominal obesity, WC>102 cm (males), >88 cm (females); hypertension, SBP ≥ 130 mmHg or DBP ≥ 85 mmHg or taking anti-hypertensive medications; HDL-C, <40 mg/dL (males), <50 mg/dL (females); high triglycerides, ≥ 150 mg/dL or taking anti-hyperlipidemic medications; high fasting glucose, ≥ 110 mg/dL or taking insulin or other hypoglycemic agents.

Statistical Analyses

Sampling weights and the primary sampling units and strata information, as provided by NHANES [20,21], were included in all analyses using SUDAAN v11.0 (Research Triangle Institute; Raleigh, NC). Least-square means (and the standard errors of the least-square means) were calculated using PROC REGRESS of SUDAAN. Linear regression was used to determine differences between chickpea/hummus consumers and non-consumers for food, nutrient, and physiologic measures. Logistic regression was used to determine if chickpea/hummus consumers had a lower odds ratio of being overweight or obese or having other adverse physiologic outcomes. For all linear and logistic regressions, covariates were age, gender, ethnicity, poverty index ratio (one of three levels: 0-1.25, 1.25-3.5, ≥ 3.5) [24], physical activity level (one of three levels: sedentary, moderate, and vigorous) [38], current smoking status, and alcohol consumption, which was obtained from the 24-hour dietary recall. Energy (kcals) was used for regressions in the nutrient analyses except when kcals were the dependent variable. Energy was also not used as a covariate in the HEI-2005 analyses, since HEI-2005 controls for energy. Body Mass Index was used as a covariate in the biophysical linear regressions except when the dependent variable was body weight, BMI, or WC. For linear regression analysis, a p<0.01 was used; however, for the logistic analysis a p value of <0.05 was considered significant.

Results

Demographics and hummus/chickpea consumption

Subjects were adults 19+ y (N=17,873; 1.48% chickpea/hummus consumers) participating in the NHANES 2003-2010. Table 1 show that overall chickpea/hummus consumers were more likely to be female, non-Hispanic White, younger, of higher income, more physically active and consumed more alcohol than non-consumers. The average amount of chickpeas/hummus consumed was 73 g/day in all adults and was considerably higher in males (99 g/d) than in females (59 g/d).

Energy, macronutrient, and micronutrient intakes

Energy intake was similar among chickpea/hummus consumers (2164 ± 66 kcals) when compared with non-consumers (2117 ± 11 kcals) (Table 2). Chickpea/hummus consumers had significantly (p<0.01) higher daily intakes of dietary fiber (24.4 ± 0.7gmvs 16.1 ± 0.1 gm); polyunsaturated fatty acids (19.5 ± 0.4 gmvs 17.3 ± 0.1 gm); vitamins A (787 ± 42 RAE mcg vs 640 ± 6 RAE mcg), C (119 ± 8 mg vs 86.4 ± 1.1 mg), E (10.1 ± 0.5 mg vs 7.5 ± 0.1 mg), and K (171 ± 13 mcg vs 101 ± 2 mcg), thiamin (1.9 ± 0.1 mg vs 1.7 ± 0.01 mg), folate (627 ± 16 mcg vs 547 ± 4 mcg), magnesium (385 ± 13 mg vs 291 ± 2 mg), potassium (3103 ± 59 mg vs 2697 ± 12 mg), copper (1.8 ± 0.1 mg vs 1.3 ± 0.02 mg), and iron (17.4 ± 0.5 mg vs 15.8 ± 0.1 mg) than non-consumers. Consumers also had lower intakes of added sugars (14.0 ± 0.8 tspeqvs 17.6 ± 0.2 tspeq), total fat (76.4 ± 1.5 gmvs 80.4 ± 0.3 gm),SFA (22.4 ± 0.7 gmvs 26.6 ± 0.1 gm), and cholesterol (227 ± 8 mg vs 288 ± 2 mg) than non-consumers.

	Consumers N=264 Mean ± SE	Non-consumers N=17,609 Mean ± SE	P Value
Age	43.1 ± 1.2	46.8 ± 0.3	0.0022
Gender - Female (%)	62.8 ± 4.0	51.4 ± 0.5	0.0047
Mexican American/Hispanic (%)	5.8 ± 1.2	12.1 ± 1.1	0.0001
Non-Hispanic White (%)	88.3 ± 2.1	71.1 ± 1.7	<0.0001
Non-Hispanic Black (%)	1.0 ± 0.4	11.6 ± 0.9	<0.0001
Poverty Income Ratio	3.9 ± 0.1	3.0 ± 0.0	<0.0001
Smoker Current (%)	15.6 ± 3.7	23.0 ± 0.7	0.0457
Physical Activity - Sedentary (%)	12.8 ± 2.5	27.8 ± 0.7	<0.0001
Physical Activity - Moderate (%)	27.2 ± 4.5	36.1 ± 0.6	0.0504
Physical Activity - Vigorous (%)	60.0 ± 4.8	36.1 ± 0.8	<0.0001
Alcohol Consumer (%)	59.3 ± 4.1	34.1 ± 0.8	<0.0001
Alcohol (gm/d)	13.2 ± 1.3	9.0 ± 0.3	0.0014

Data Source: Participants 19 years and older of the NHANES 2003-2010
P<0.01

Table 1: Demographic and lifestyle characteristics of the adults aged 19+ years participating in the national health and nutrition examination survey 2003-2010 characterized by chickpea/hummus consumption.

Nutrients[1]	Consumers Mean ± SE	Non-consumers Mean ± SE	P Value
Energy[2]	2163.6 ± 65.5	2116.5 ± 10.7	0.4961
Protein (gm)	82.8 ± 2.1	83.0 ± 0.3	0.9324
Added sugars (tspeq)	14.0 ± 0.8	17.6 ± 0.2	<0.0001
Dietary fiber (gm)	24.4 ± 0.7	16.1 ± 0.1	<0.0001
Total fat (gm)	76.4 ± 1.5	80.4 ± 0.3	0.0073
Monounsaturated fatty acids (gm)	28.0 ± 0.7	29.5 ± 0.1	0.0501
Polyunsaturated fatty acids (gm)	19.5 ± 0.4	17.3 ± 0.1	<0.0001
Saturated fatty acids (gm)	22.4 ± 0.7	26.6 ± 0.1	<0.0001
Cholesterol (mg)	226.6 ± 8.3	288.0 ± 2.2	<0.0001
Vitamin A, RAE (mcg)	787.2 ± 42.3	640.2 ± 6.0	0.0014
Thiamin (mg)	1.9 ± 0.1	1.7 ± 0.0	0.0010
Riboflavin (mg)	2.2 ± 0.1	2.2 ± 0.0	0.8228
Niacin (mg)	25.3 ± 0.8	25.3 ± 0.1	1.0000
Folate, DFE (mcg)	627.3 ± 16.3	546.8 ± 4.3	<0.0001
Vitamin B6 (mg)	2.2 ± 0.1	2.0 ± 0.0	0.0389
Vitamin B12 (mcg)	5.1 ± 0.3	5.5 ± 0.1	0.2222
Vitamin C (mg)	118.8 ± 7.6	86.4 ± 1.1	0.0001
Vitamin D (D2 + D3) (mcg)	5.1 ± 0.5	4.8 ± 0.1	0.5841
Vitamin E α-tocopherol (mg)	10.1 ± 0.5	7.5 ± 0.1	<0.0001
Vitamin K (mcg)	171.0 ± 13.0	100.8 ± 1.7	<0.0001
Total choline (mg)	330.6 ± 8.2	329.8 ± 1.8	0.9214
Calcium (mg)	953.0 ± 25.4	937.4 ± 6.2	0.5252
Magnesium (mg)	385.4 ± 12.9	291.2 ± 1.6	<0.0001
Phosphorus (mg)	1412.4 ± 27.2	1348.7 ± 4.3	0.0187
Potassium (mg)	3103.1 ± 59.2	2697.1 ± 11.5	<0.0001
Sodium (mg)	3530.4 ± 73.1	3607.1 ± 11.0	0.2832
Copper (mg)	1.8 ± 0.1	1.3 ± 0.0	<0.0001
Iron (mg)	17.4 ± 0.5	15.8 ± 0.1	0.0028
Selenium (mcg)	115.7 ± 2.8	111.4 ± 0.6	0.1338
Zinc (mg)	12.1 ± 0.4	12.2 ± 0.1	0.7796

Data Source: Participants 19 years and older of the NHANES 2003-2010
[1]Covariates for nutrients: gender, ethnicity, age, poverty income ratio, physical activity, smoker status, alcohol, and energy (kcals)
[2]Covariates for energy: gender, ethnicity, age, poverty income ratio, physical activity, smoker status, alcohol

Table 2: Energy and nutrient intake by chickpea/hummus consumer status.

Diet quality

Diet quality, measured by HEI, was higher in adult chickpea/hummus consumers (62.2 ± 1.3 vs 51.9 ± 0.2) as compared to non-consumers, respectively (Table 3). The higher HEI score in consumers was driven by better scores for the HEI subcomponents: total (2.9 ± 0.2 vs 2.3 ± 0.03) and whole fruit (2.7 ± 0.2vs 2.04 ± 0.03), total (3.8 ± 0.1 vs 3.1 ± 0.02) and dark green and orange vegetables (2.7 ± 0.1 vs 1.3 ± 0.02), whole grains (1.8 ± 0.1 vs 1.1 ± 0.02),oils (7.2 ± 0.2 vs 5.8 ± 0.03), SFA (7.2 ± 0.3 vs 5.8 ± 0.04), and calories from solid fats, alcohol, and added sugars (13.2 ± 0.5 vs 10.0 ± 0.1).

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Diet Quality Score and Components	Consumers Mean ± SE	Non-consumers Mean ± SE	P Value
Healthy Eating Index	62.15 ± 1.31	51.91 ± 0.20	<0.0001
HEI Component 1 (Total Fruit)	2.93 ± 0.17	2.25 ± 0.03	0.0004
HEI Component 2 (Whole Fruit)	2.70 ± 0.17	2.04 ± 0.03	0.0005
HEI Component 3 (Total Vegetable)	3.82 ± 0.08	3.11 ± 0.02	<0.0001
HEI Component 4 (DrkGrn& Orange Veg)	2.69 ± 0.13	1.25 ± 0.02	<0.0001
HEI Component 5 (Total Grains)	4.28 ± 0.10	4.20 ± 0.01	0.3895
HEI Component 6 (Whole Grains)	1.82 ± 0.13	1.14 ± 0.02	<0.0001
HEI Component 7 (Milk)	4.74 ± 0.17	5.01 ± 0.05	0.0942
HEI Component 8 (Meat and Beans)	8.01 ± 0.24	8.10 ± 0.03	0.7036
HEI Component 9 (Oils)	7.18 ± 0.18	5.77 ± 0.03	<0.0001
HEI Component 10 (Saturated Fat)	7.20 ± 0.26	5.80 ± 0.04	<0.0001
HEI Component 11 (Sodium)	3.55 ± 0.21	3.25 ± 0.03	0.1434
HEI Component 12 (SoFAAS)	13.24 ± 0.50	10.00 ± 0.09	<0.0001

Data Source: Participants 19 years and older in the NHANES 2003-2010
Covariates: gender, ethnicity, age, poverty income ratio, physical activity, smoker status, alcohol

Table 3: Diet quality, as determined by the Healthy Eating Index-2005 among chickpea/hummus consumers and non-consumers.

Physiologic Outcomes	Consumers Mean ± SE	Non-consumers Mean ± SE	P Value
Weight (kg)	75.75 ± 1.58	81.93 ± 0.31	0.0002
Body Mass Index (kg/m^2)	26.44 ± 0.52	28.60 ± 0.11	0.0001
Waist Circumference (cm)	92.17 ± 1.28	97.89 ± 0.25	<0.0001
LDL-cholesterol (mg/dL)*	112.13 ± 5.60	116.29 ± 0.55	0.4653
HDL-cholesterol (mg/dL)*	56.73 ± 1.49	54.05 ± 0.22	0.0705
Triglyceride (mg/dL)*	126.55 ± 7.92	136.70 ± 1.68	0.2189
C-reactive protein(mg/dL)*	0.36 ± 0.04	0.42 ± 0.01	0.1768
BP Diastolic (mm Hg)*	68.89 ± 1.14	70.87 ± 0.26	0.1028
BP Systolic (mm Hg)*	120.02 ± 1.17	122.27 ± 0.24	0.0607
Glucose, plasma (mg/dL)*	103.14 ± 2.31	103.30 ± 0.40	0.9484
Insulin (uU/mL)*	11.99 ± 0.60	11.72 ± 0.16	0.6559
HOMA-IR*	3.75 ± 0.43	3.37 ± 0.05	0.3827

Data Source: Participants 19 years and older in the NHANES 2003-2010
Covariates: gender, ethnicity, age, poverty income ratio, physical activity, smoker status, alcohol; those outcomes marked with * also had BMI as a covariate
Abbreviations: LDL=low-density cholesterol, HDL=high-density cholesterol, BP=blood pressure; HOMA-IR=Homeostasis Model of Assessment - Insulin Resistance

Table 4: Physiologic outcomes among adult chickpea/hummus consumers and non-consumers.

Anthropometric and physiologic measures

Adult chickpea/hummus consumers had a lower body weight (75.8 ± 1.6 kg vs 81.9 ± 0.3 kg), smaller WC (92.2 ± 1.3 cm vs 97.9 ± 0.3 cm), and lower BMI (26.4 ± 0.5 vs 28.6 ± 0.1) than non-consumers (Table 4). There were no significant differences shown in any of the other physiologic outcomes examined. As compared to non-consumers, adult chickpea/hummus consumers were 53% less likely to be obese, 43% less likely to be overweight or obese, a 48% reduced risk of increase WC, and 51% less likely to have an elevated glucose level (Table 5).

Discussion

This is the first published study showing the association between nutrient intake, diet quality, and cardiovascular risk factors in chickpea/hummus consumers. Chickpea/hummus consumption was associated with better nutrient intake and diet quality than seen in non-consumers. Weight and adiposity parameters were also better among chickpea/hummus consumers than non-consumers. The likelihood of a lower risk for elevated fasting glucose levels was the only other CVRF that was affected by chickpea/hummus consumption in this population.

The number of consumers of chickpeas/hummus was very low with only 1.5% of the population consuming these foods, but this still represents over 4 million people. This study made no distinction between consumption of canned or dried chickpeas; however, the majority of information available on production is for total dried bean consumption. The percentage of chickpea/hummus consumers in this study is in sharp contrast with the USDA figures for overall dried bean consumption of 14% [5] (chickpea consumption *per se* is not available). The Economic Research Service should provide more explicit information on types of dried beans consumed and should also provide information on consumption of canned beans. The low percentage of consumers in this study reflects data from other studies reporting that overall consumption of beans in general [39,40], and suggests that people are not meeting the recommended consumption of 1½ cups per week [41].

The principal barriers to consuming dried beans include unfamiliarity with the product and preparation time [42,43]. Unlike canned beans, which are cooked when purchased, dried beans require a significant amount of preparation time? Dried beans are usually soaked and then cooked for an additional1to 2 hours [44]. In focus group discussions, specific barriers to consumption of canned chickpeas included the perception that they limited other food choices and were associated with perceived negative health consequences, including bloating, frequent defecation, and feeling "heavy" [45].

Consumption of chickpeas/hummus was associated with higher intake of several nutrients of public health concern [41], including dietary fiber and potassium, as well as higher intakes of shortfall nutrients for some populations, including vitamins A, E, and C; folate; iron and magnesium [41]. The higher mean dietary fiber intake among chickpea/hummus consumers (+8.3 g/d) was not surprising since chickpeas have 6.3 g dietary fiber/½ cup serving and commercially available hummus has 1.7 g of dietary fiber/28 g serving [8]. Chickpea feeding studies also showed an increase in dietary fiber intake during the "chickpea phase" of the study [7,45]. On average, however, the dietary fiber intake seen in this study was higher than that contributed

Physiologic Outcomes	Consumers Mean ± SE	Non-consumers Mean ± SE	P Value
Weight (kg)	75.75 ± 1.58	81.93 ± 0.31	0.0002
Body Mass Index (kg/m^2)	26.44 ± 0.52	28.60 ± 0.11	0.0001
Waist Circumference (cm)	92.17 ± 1.28	97.89 ± 0.25	<0.0001
LDL-cholesterol (mg/dL)*	112.13 ± 5.60	116.29 ± 0.55	0.4653
HDL-cholesterol (mg/dL)*	56.73 ± 1.49	54.05 ± 0.22	0.0705
Triglyceride (mg/dL)*	126.55 ± 7.92	136.70 ± 1.68	0.2189
C-reactive protein(mg/dL)*	0.36 ± 0.04	0.42 ± 0.01	0.1768
BP Diastolic (mm Hg)*	68.89 ± 1.14	70.87 ± 0.26	0.1028
BP Systolic (mm Hg)*	120.02 ± 1.17	122.27 ± 0.24	0.0607
Glucose, plasma (mg/dL)*	103.14 ± 2.31	103.30 ± 0.40	0.9484
Insulin (uU/mL)*	11.99 ± 0.60	11.72 ± 0.16	0.6559
HOMA-IR*	3.75 ± 0.43	3.37 ± 0.05	0.3827

Data Source: Participants 19 years and older in the NHANES 2003-2010
Covariates: gender, ethnicity, age, poverty income ratio, physical activity, smoker status, alcohol; those outcomes marked with * also had BMI as a covariate
Abbreviations: LDL=low-density cholesterol, HDL=high-density cholesterol, BP=blood pressure; HOMA-IR=Homeostasis Model of Assessment - Insulin Resistance

Table 5: Odds ratios for physiological outcomes among adult consumers of chickpea/hummus compared to non-consumers.

by the average amount of chickpeas consumed. The same was true of potassium. Chickpea consumers had mean higher intakes of potassium than the potassium in the mean amount of chickpeas consumed contained. This difference was likely accounted for by the finding that chickpea consumers also had higher consumption of other dietary fiber and potassium containing foods, such as whole fruit, total vegetables, and whole grains. This suggests that chickpea/hummus consumers may have an overall healthier diet than non-consumers and this was reflected in their higher diet quality.

Intake of PUFA was also higher in chickpea/hummus consumers when compared with non-consumers, despite the overall lower intake of total fat. Pittaway et al. [7] also showed that in a feeding study, during the chickpea consumption phase, PUFA intake was higher. Although small amounts of PUFA (3.8-10% [6]) are found in chickpeas, the levels are not high enough to be considered an oilseed crop. Thus, the higher intake of PUFA likely came from other food choices or from preparation methods of the chickpeas, for example as hummus [8].

There was no difference in sodium intake between chickpea/hummus consumers and non-consumers, although mean intake of both groups exceeded recommendations [46]. This is an important consideration if consumers select canned chickpeas (311 mg sodium/½ cup [8]) or commercially available hummus (106 mg sodium/28 g [8]); these figures compare with cooked unsalted chickpeas (5.5 mg sodium/½ cup [8]) and home-made hummus (68 mg sodium/28 g [8]). It should be noted that the sodium content in canned beans can be reduced significantly by simply rinsing the beans.

Consumption of chickpeas/hummus was associated with lower weight, BMI, and WC, as well as a lower risk of obesity, overweight/obesity and high WC than those seen in non-consumers. This was seen despite the finding that there was no difference in energy intake between consumers and non-consumers. Pulse consumption, although not specifically chickpea/hummus, has been shown previously, in epidemiologic studies, to be associated with lower weight and adiposity measures [47]. Pulse consumption in clinical feeding trials has also been shown to reduce weight, although these studies usually also included a hypoenergetic diet [17,48,49]. A number of nutrients and anti-nutritional factors found in pulses, including chickpeas, may be associated with weight management. The carbohydrates are slowly digested; in chickpeas, approximately one-third of the starch is amylose [50] which is resistant to rapid and total hydrolysis in the small intestine, thus, having a lower bioavailability [11]. Pulses are high in dietary fiber [8]. Although the relationship between fiber and weight is limited [51,52], some studies have shown those consuming more fiber weigh less than those consuming less fiber [52-55]. Pulses, including chickpeas have been reported to increase satiety, which may limit energy intake; however, this has not been reported in the chickpea feeding study which determined satiety [45]. The protein content and anti-nutrient factors have also been reported as potential mechanisms for weight management in pulse consumers [16].

The only other difference seen among the CVRF was the likelihood of an elevated fasting glucose level. This is partially supported by a small feeding study (n=19) has also shown that a single meal containing chickpeas (200 g) lowered plasma glucose, insulin, and HOMA-IR; however, these findings could not be replicated in a 6 week feeding trial (140gm/d of chickpeas and baked goods with 30% chickpea flour) [10]. This study did not show differences in in elevated insulin and hence in HOMA-IR, although this may reflect the amount consumed in the larger free-living population as opposed small feeding study.

There were no other differences in CVRF between chickpea/hummus consumers and non-consumers were seen. Previous studies have shown that pulses [56,57], including chickpeas [8,18,19] lower serum cholesterol levels. The studies involving chickpeas were short term feeing studies with relatively large amounts of chickpeas (105 gm/d) or chickpea products. It's likely that chickpea consumption in this study was not high enough to influence these CVRF.

Strengths and Limitations

This study included a large sample size with a nationally representative sample. The NHANES has carefully controlled protocols and screens 24-hour dietary recalls to confirm they are valid and complete; as stated, the NHANES also uses the multiple pass method to obtain dietary intake. However, 24-hour dietary recalls have several intrinsic limitations. They are memory dependent and over- or under-reporting of intake may occur. Further, since causal inferences cannot be drawn from cross-sectional analyses, and due to multi-co-linearity of diet, foods other than chickpeas/hummus may have contributed to differences in nutrient intake of the participants. Although, this was not examined, it's is also possible that chickpea consumers are vegetarians and may have an overall more healthy diet. Finally, there were relatively small numbers of chickpea/hummus consumers and average consumption was low.

Conclusions and Recommendations

Chickpea/hummus consumption was associated with a better nutrient profile, diet quality, lower BMI and WC, and lower risk of obesity and of high WC than seen in non-consumers. There was also a lower likelihood of elevated fasting glucose levels. These findings suggest that additional studies, not only of chickpeas/hummus are Chickpea/hummus consumption, in common with other pulses, should be encouraged, as part of an overall health diet, by health professionals, including registered dietitians; nutrition education programs that increase awareness and consumption of chickpea/hummus should be designed and delivered. These programs should be designed to overcome barriers to consumption that have been cited previously, including inconvenience, sensory properties of the product, and health upsets [45].

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