applied sciences

MDPI

Article

Dietary Patterns and Nutritional Status in Relation to Consumption of Chickpeas and Hummus in the U.S. Population

Cara L. Frankenfeld [1] and Taylor C. Wallace [2,3,*]

1 Department of Global and Community Health, George Mason University, Fairfax, VA 22030, USA; cfranken@gmu.edu
2 Department of Nutrition and Food Studies, George Mason University, Fairfax, VA 22030, USA
3 Think Healthy Group Inc., Washington, DC 20036, USA
* Correspondence: taylor.wallace@me.com; Tel.: +1-(270)-839-1776

Received: 25 September 2020; Accepted: 16 October 2020; Published: 20 October 2020

Abstract: Chickpeas, a commonly consumed legume, are the main ingredient in traditional hummus. U.S. dietary guidelines recommend consuming 1–1.5 cups of legumes per week. This study aimed to evaluate temporal changes in hummus and chickpea consumption and describe diet and biomarkers of health in U.S. consumers versus non-consumers. National Health and Nutrition Examination Survey (2005–2016) data were used. Dietary intake was collected using two 24-h recalls; age, gender, and poverty-to-income ratio were adjusted in statistical analyses. The proportion of the population who consumed chickpeas or hummus increased significantly over time. Hummus and chickpea consumers were more likely to obtain recommended legume intake. Consumers had significantly increased intakes of fruits, vegetables, and whole grains and decreased added sugars intakes versus non-consumers. Consumers also had lower concentrations of urinary iodine and higher concentrations of serum 4-pyridoxic acid, total vitamin B6, and red blood cell folate. Adults who consumed chickpeas and hummus were 48% and 62% less likely to have metabolic syndrome, respectively. Consuming chickpeas or hummus may be a practical means of improving diet quality and nutritional status. Future work should evaluate whether chronic disease incidence is reduced by chickpea and hummus consumption through better nutrition or lower metabolic syndrome incidence.

Keywords: chickpeas; hummus; nutrition; NHANES; legume

1. Introduction

Dietary pulses, the edible seeds of legumes (e.g., beans, lentils, chickpeas, and peas), are sustainable plant-protein sources that are also high in fiber and various micronutrients [1–3]. The Dietary Guidelines for Americans (DGA) first recommended the inclusion of legumes in the 2005 iteration [4]. The 2015 DGA now recommends that Americans consume 1–1.5 cups of legumes per week [5]. Despite these recommendations, toddlers aged 1–3 years are the only group in the United States that consumes adequate amounts of legumes [5]. This is relevant given that legume and pulse consumption has been associated with a wide array of health benefits, particularly reduced cardiometabolic risk when consumed as part of a healthy overall dietary pattern [6–12]. The inverse relationship between legumes and risk of coronary heart disease is apparent at doses ≥4 servings per week among prospective cohort studies [11,12]. Further, doses of about 1 serving per day have shown meaningful reductions in cardiometabolic risk factors such as body weight, blood pressure, and hemoglobin A1C [6–8,12]. Chickpea (*Cicer arietinum* L.), also commonly known as garbanzo beans, is a commonly consumed pulse that has grown popular in Western culture due to its nutty flavor profile and versatile sensory applications in food [13]. Hummus is a traditional dip or spread made from cooked, mashed chickpeas that are blended with tahini, olive oil, lemon juice, and spices, although other varieties exist [13]. In Western culture, chickpea consumption is at least somewhat driven through intake of hummus [14]. The worldwide hummus market alone grew to over $780 million in 2019 and is expected to exceed $910 million by 2024 [15]. The United States and Middle East hold the largest market shares in terms of value. The United States accounts for a little over one-third of the global hummus market [16]. The consumption of chickpeas and hummus has been associated with increased intakes of several nutrients, including fiber, polyunsaturated fatty acids, vitamin A, thiamin, folate, vitamin B_6, vitamin C, vitamin E, vitamin K, magnesium, phosphorus, potassium, copper, and iron, as well as decreased intakes of added sugars, total fat, monounsaturated fatty acids, saturated fatty acids, and cholesterol [14]. Four tablespoons (≈140 kcal) of traditional hummus per day provides approximately 25 g of dietary fiber—a shortfall nutrient in the diets of many adults and children [13]. Both raw and cooked chickpeas also contain dietary bioactive compounds such as polyphenols, carotenoids, sterols, and phytic acid, whose health-promoting benefits may extend beyond helping meet basic human nutrition requirements [17,18]. The nutritional value and health benefits associated with chickpea and/or hummus consumption has been reviewed by our group and others [13,17,18]. Acute consumption of an afternoon hummus snack was recently shown to improve diet quality and selected indices of appetite, satiety, and glycemic control in healthy adults ($n = 38$). Notably, hummus consumption reduced the amount of subsequent snacking on desserts by approximately 20% [19].

The overall goals of this research were to evaluate temporal changes in hummus and chickpea consumption in the United States, as well as describe eating patterns, nutritional status, and differences in biomarkers of health among chickpea consumers versus non-consumers. This work specifically contributes to understanding characteristics of chickpea and hummus consumers and serves as a foundation to evaluate whether recommendations for chickpea and hummus consumption could improve individual health.

2. Materials and Methods

Data from the National Health and Nutrition Examination Survey (NHANES) (2005–2016) were used for analysis. NHANES is a nationally representative survey of the non-institutionalized U.S. population that is conducted on an ongoing basis, with data releases provided in 2-year cycles [20,21]. Data collection included interviews conducted in the home, in the Mobile Examination Center (MEC), and over the phone and in-person measurements of body measures and biospecimens. Publicly available data were obtained from the Centers for Disease Control and Prevention National Center for Health Statistics [20,21].

2.1. Demographic and Socioeconomic Characteristics

Age and gender were self-reported variables in NHANES. Age was reported to the nearest year, and all individuals aged ≥85 were classified as age 85 years to ensure confidentiality in the public release data. Gender categories included in NHANES were male and female. There were no missing data for age or gender in NHANES. Individuals were excluded if they were younger than age 2 years. Family poverty-to-income ratio (PIR) was calculated based on reported income, and individuals with a PIR > 5 were classified as having a PIR of 5 to ensure confidentiality. In this analysis, PIR was used to estimate socioeconomic status. Individuals were excluded if PIR was missing.

2.2. Dietary Intake

Dietary intake in NHANES participants was ascertained through two 24-h recalls. The first 24-h recall (referred to as day 1 intake) was conducted in the MEC, and the second 24-h recall (day 2 intake) was conducted via telephone 3–10 days after the first recall [22]. Dietary intake data were provided as individual foods files and total nutrient intake files. Individual foods files were used to identify and estimate total hummus and chickpea consumption and identify meals in which foods were consumed. Individuals were excluded if there were missing data for either dietary recall or if the average total kilocalorie consumption across the two 24-h recalls was <500 or >5000 kcal.

Individual foods were identified as hummus or chickpeas based on the U.S. Department of Agriculture (USDA) eight-digit food code (Table 1). This information is used to classify individual foods reported by the individual as either being or containing hummus or chickpeas, and from that information, the classification of being a consumer and how much can be made. Each food reported by an individual was classified as hummus or chickpea. The total amount of hummus and chickpea foods consumed at each meal was calculated for each person in grams. There were 20 possible meal types in NHANES that include options in Spanish and extended consumption, and meals were classified into 5 groups: breakfast (breakfast, desayuno), lunch (lunch, brunch, almuerzo), dinner (dinner, supper, cena), snack (snack, entre comida, botana, bocadillo, tentempié), and other (drink, infant feeding, extended consumption, comida, merienda, bebida, other). Individuals were classified as consuming hummus or chickpeas on day 1 and day 2. Each individual was also classified as having consumed hummus or chickpeas on either day.

Table 1. Classification of foods as hummus or chickpeas based on eight-digit U.S. Department of Agriculture (USDA) food code. [1]

USDA Food Code	Food Description	Included Hummus	Included Chickpeas
41205070	Hummus, plain	X	X
41205075	Hummus, flavored	X	X
41302000	Chickpeas, dry, cooked, NS as to fat added in cooking		X
41302010	Chickpeas, dry, cooked, fat added in cooking, NS as to type of fat		X
41302011	Chickpeas, dry, cooked, made with oil		X
41302012	Chickpeas, dry, cooked, made with animal fat or meat drippings		X
41302013	Chickpeas, dry, cooked, made with margarine		X
41302020	Chickpeas, dry, cooked, fat not added in cooking		X
41302030	Chickpeas, canned, drained, NS as to fat added in cooking		X
41302040	Chickpeas, canned, drained, fat added in cooking, NS as to type of fat		X
41302050	Chickpeas, canned, drained, made with oil		X
41302080	Chickpeas, canned, drained, fat not added in cooking		X
41302100	Chickpeas, canned, drained, low sodium, NS as to fat added in cooking		X
41302110	Chickpeas, canned, drained, low sodium, fat added in cooking		X
41302120	Chickpeas, canned, drained, low sodium, fat not added in cooking		X
41310150	Stewed chickpeas, Puerto Rican style		X
41310160	Stewed chickpeas, with potatoes, Puerto Rican style		X
41310200	Chickpeas stewed with pig's feet, Puerto Rican style		X
41310210	Stewed chickpeas with Spanish sausages, Puerto Rican style		X
41310220	Fried chickpeas with bacon, Puerto Rican style		X
41602020	Garbanzo bean or chickpea soup, home recipe, canned or ready-to-serve		X
75302029	Beans, string, green, with chickpeas, cooked, NS as to fat added in cooking		X
75302030	Beans, string, green, with chickpeas, cooked, fat not added in cooking		X
75302031	Beans, string, green, with chickpeas, cooked, fat added in cooking		X

[1] NS: not specified; USDA, U.S. Department of Agriculture.

The USDA provides food pattern equivalents for NHANES, and this information was merged with the other NHANES files [23]. Food pattern equivalents for vegetables (cup equivalents), fruits (cup equivalents), whole grains (ounce equivalents), and added sugars (in grams) were used to describe dietary characteristics to compare across hummus and chickpea consumers. Additional food pattern equivalents were used to calculate total legume consumption, and individuals were classified as meeting legume recommendations based on their average kilocalorie intake over the 2 days of recalls as follows: ≥0.5 cup-equivalent/week for <1500 kcal, ≥1 cup-equivalent/week for ≥1500 to <1700 kcal, and ≥1.5 cup-equivalent/week for ≥1700 kcal.

2.3. Anthropometry and Blood Pressure

Trained technicians took NHANES participants' physical measurements according to an established set of protocols [20]. All individuals were eligible for the body measure components of the NHANES in-person visit. Measured weight (in kilograms) and waist circumference (in centimeters) and calculated body mass index (BMI; in kilograms per square meter) based on measured weight and height were used in this analysis. Three consecutive blood pressure measurements were taken.

Blood pressure was measured in NHANES participants aged >8 years. The average of available measurements for systolic and diastolic blood pressure (in millimeters of mercury) was used in this analysis (e.g., average of 3 measurements if all 3 were available; average of 2 measurements if only 2 were available).

2.4. Urine and Blood Biospecimens

NHANES participants provided urine and blood samples during the in-person visit to the MEC. Participants were not required to be fasted, so a subset of participants who happened to be fasted were eligible for fasting measurements. Measurements from urine and blood biospecimens used in the analysis for the evaluation of dietary biomarkers included urinary iodine and serum selenium, copper, zinc, vitamin D (D_2 + D_3), vitamin B_{12}, vitamin B_6 (4-pyridoxic acid, pyridoxal 5′-phosphate, and serum B_6), and red blood cell folate.

Fasting blood biospecimens were also evaluated for high-density lipoprotein (HDL) cholesterol, triglycerides, and glucose according to established protocols [20], and these values were used in the calculation of metabolic syndrome (MetS) classification.

2.5. Metabolic Syndrome

MetS was calculated for adults only (age ≥ 20 years) due to a lack of collection of all the component biomarkers in younger populations, per NHANES protocols. Individuals were classified as having MetS based on having 3 or more of the following 5 National Cholesterol Education Program's Adult Treatment Program III (ATPIII) criteria: abdominal obesity (waist circumference, >88 cm for women and >102 cm for men), high triglycerides (fasting triglycerides, >150 mg/dL), low HDL (<50 mg/dL for women, <40 mg/dL for men), high blood pressure (systolic, ≥135 mm Hg; diastolic, ≥85 mm Hg), and high fasting blood glucose (≥110 mg/dL) [24].

2.6. Statistical Analysis

There were 60,936 individuals in the NHANES 2005–2016 data releases. The following exclusions were applied for the main analyses (in order of application) to include 37,552 individuals: age ≤ 2 years (n = 6280), no day 2 dietary recall (n = 12,524), missing PIR data (n = 3042), average intake < 500 kcal (n = 113), average intake > 5000 kcal (n = 161), missing anthropometry data (n = 1261), and missing dietary intake data for day 1 (n = 3). Smaller numbers of individuals were included for biomarker measurements based on the years of the data available and the availability of measurements for individuals. The data release years and sample sizes for these analyses were as follows: urinary iodine (2005–2016; n = 15,412); red blood cell folate (2005–2016; n = 34,893); serum vitamin D (2009–2016; n = 22,549); serum copper, selenium, and zinc (2011–2016; n = 5157); serum B_{12} (2005–2006 and 2011–2012; n = 9840); serum B_6 (2005–2010; n = 18,002); and MetS (2005–2016; n = 13,429). NHANES provided population weights for each of the data releases, and all analyses applied appropriate survey weighting for the variables [20]. Where possible, data from all data releases were used; however, for some of the urinary and blood measurements, these variables were only available for a smaller number of data releases as previously indicated, and the population weights were divided by the number of cycles utilized for the analysis. For descriptive statistics, frequencies and population-weighted percentages were calculated for dichotomous or categorical outcomes. Means and population-weighted standard errors were calculated for numerical outcomes. Arithmetic means were used for variables that were reasonably normally distributed upon visual inspection of the histogram. Geometric means were used for variables that had a skewed distribution. Multivariable logistic or linear regression analyses were used to model associations for dichotomous and numerical dependent variables, respectively, with age, gender, and PIR included as adjustment variables. Analyses were conducted using Stata software (version 15; StataCorp LLC, College Station, TX, USA).

3. Results

3.1. Temporal Changes in Hummus and Chickpea Consumption in the U.S. Population

The percentage of individuals who reported hummus or chickpea consumption has increased in the population over time (Figure 1). In the population as a whole, there were statistically significant increasing trends in the percentage of consumers of hummus (p-trend < 0.001) and chickpeas (p-trend < 0.001) when adjusted for age, gender, and PIR. Females had higher hummus and chickpea consumption than males, but this was less apparent in more recent years; both groups had significant increases over time in the percentage of population who were consumers of hummus (p-trend = 0.002 for males and 0.001 for females) and chickpeas (p-trend = 0.007 for males and 0.001 for females), adjusted for age and PIR. With regard to age, children had the lowest percentage of hummus and chickpea consumption. All age groups exhibited increases in the percentage of hummus and chickpea consumers over time (p-trend < 0.05 for all groups). Higher-income individuals had the highest percentages of hummus and chickpea consumers in the population. After adjustment for gender and age, middle-income and higher-income groups had increased percentages of hummus and chickpea consumers over time (p-trend < 0.05 all groups), and lower-income groups had an increase in the percentage of hummus consumers (p-trend < 0.05) but not chickpea consumers.

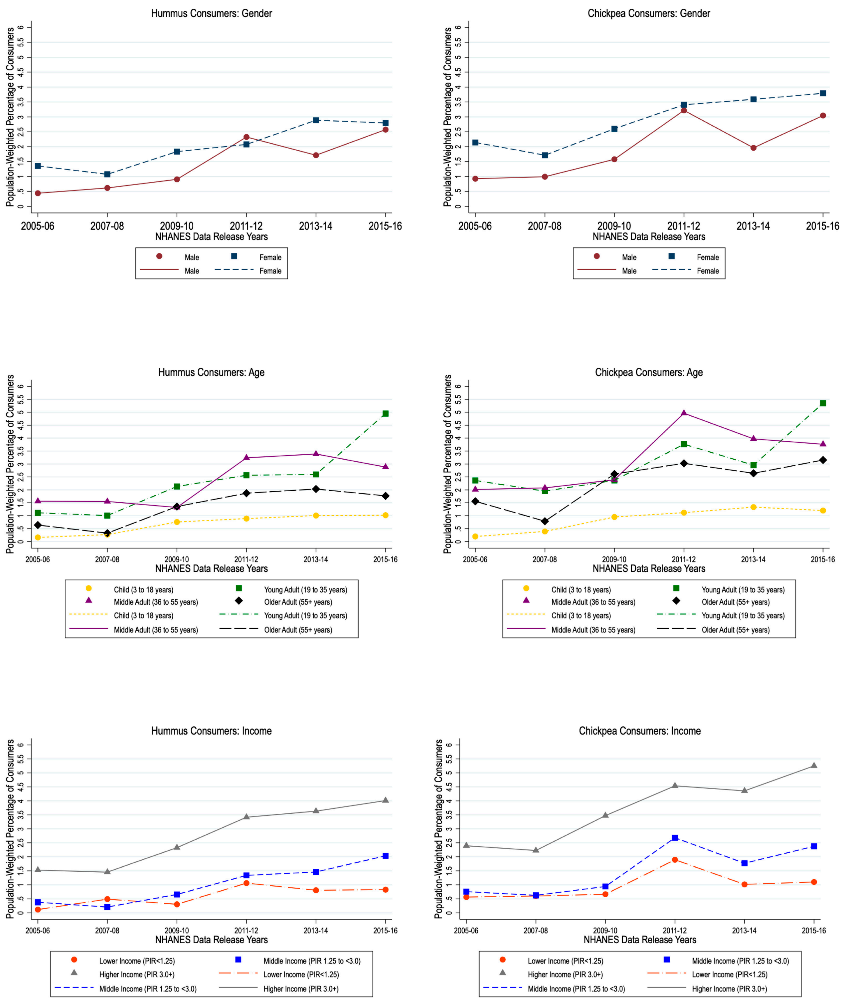

Figure 1. Percentage in each NHANES data release year of hummus and chickpea consumers in children and adults in the U.S. population over time, stratified by age, gender, and income, using NHANES 2005–2016 data. NHANES, National Health and Nutrition Examination Survey; PIR, poverty-to-income ratio.

3.2. Dietary Patterns of Hummus and Chickpea Consumers

Across all of the data releases (2005–2016), the population-weighted percentage of individuals who consumed hummus on one or both days was 1.96%: 162 individuals reported hummus consumption on day 1 (0.71%), 189 individuals reported hummus consumption on day 2 (1.03%), and 41 individuals consumed hummus on both days (0.23%). Across all of the data releases (2005–2016), the population-weighted percentage of individuals who consumed chickpeas on one or both days was 2.84%. The results showed that 252 individuals reported chickpea consumption on day 1 (1.06%), 316 individuals reported chickpea consumption on day 2 (1.51%), and 54 individuals consumed chickpeas on both days (0.27%).

Of individuals who reported hummus consumption, the majority reported consuming it once per day (91% for day 1, 89% for day 2) (Table 2). No one reported consuming hummus >4 times per day. Among hummus consumers for each of the days, the most frequently reported meals for consumption were lunch, dinner, and snacks. A small percentage of individuals indicated consumption of hummus at breakfast and other times, and the mean amount consumed at breakfast was lower than other eating occasions.

Table 2. Frequency and mean consumption of hummus and chickpeas at different meal occasions in children and adults (age ≥ 2 years), aggregated across NHANES 2005–2016 [1].

Consumption	Measure	Breakfast	Lunch	Dinner	Snack
Hummus					
Day 1	Consumed at this eating occasion (%) [2]	1.8	44.0	26.8	33.9
	Mean amount consumed (g)	47.8 (21.6)	72.1 (11.5)	66.2 (9.8)	61.6 (6.8)
Day 2	Consumed at this eating occasion (%)	5.4	33.2	20.8	46.7
	Mean amount consumed (g)	40.9 (16.9)	60.8 (9.6)	112.5 (20.1)	57.3 (7.0)
Chickpeas					
Day 1	Consumed at this eating occasion (%)	2.7	43.0	33.6	26.9
	Mean amount consumed (g)	67.3 (22.1)	69.9 (9.1)	79.5 (19.5)	59.7 (6.9)
Day 2	Consumed at this eating occasion (%)	4.8	33.4	31.7	34.4
	Mean amount consumed (g)	43.7 (14.2)	60.9 (7.9)	85.9 (17.2)	72.9 (13.8)

[1] Values are presented as percentages or means (SE). Other meal occasions are not presented due to low frequency (<1% of population). NHANES, National Health and Nutrition Examination Survey; [2] Percentages sum to >100 because some individuals consumed hummus or chickpeas more than once per day.

Of the individuals who reported chickpea consumption, the majority reported consuming it once or twice per day (93% on day 1, 92% on day 2). The highest frequency of chickpea consumption was eight times per day. Chickpeas were most often consumed at lunch, dinner, or snacks. Small percentages of individuals reported eating chickpeas at breakfast and other occasions.

Snacking was more common among hummus consumers versus non-consumers on the day of hummus consumption. Among hummus consumers, snacking was reported by 89.5% on day 1 and 88.0% on day 2 compared with 79.5% on day 1 and 79.6% on day 2 for non-consumers. After adjustment for age, gender, and income, hummus consumers were approximately 2-fold more likely to report snacking on the same day as hummus consumption (day 1: odds ratio (OR) = 1.9 (95% confidence interval, 1.3, 2.9); day 2: OR = 2.4 (95% CI, 1.5, 3.9)). Chickpea consumers were more likely to report snacking (day 1: OR = 1.8 (95% CI, 1.3, 2.5); day 2: OR = 1.5 (95% CI, 1.02, 2.34)).

A higher percentage of individuals who consumed hummus on either day met the recommended intakes of legumes (69.7%) versus individuals who did not consume hummus (23.9%). This difference represented an eight-times higher likelihood of meeting legume consumption recommendations among hummus consumers, after adjustment for age, gender, and PIR (OR = 7.8 [95% CI, 5.6, 10.9]). A higher percentage of individuals who consumed chickpeas on either day met recommended intakes of legumes (72.6%) versus individuals who did not consume chickpeas (23.5%). This difference represented a nine-times higher likelihood of meeting legume consumption recommendations in chickpea consumers, after adjustment for age, gender, and PIR (OR = 9.2 (95% CI, 7.0, 12.0)).

Hummus and chickpea consumers had higher intakes of fruits, total and dark green vegetables, total protein foods, whole grains, and lower intakes of meat and added sugars compared to non-consumers, adjusted for age, gender, and PIR (Table 3). No differences across groups were observed for refined grain or dairy consumption.

Table 3. Consumption of fruits, vegetables, whole grains, and added sugars in hummus and chickpea consumers and non-consumers in U.S. children and adults, aggregated across NHANES 2005–2016 [1].

Food Group	Hummus			Chickpea		
	Consumers (n = 392)	Non-Consumers (n = 37,160)	p [2]	Consumers (n = 622)	Non-Consumers (n = 36,930)	p
Fruit (cup eq.)	1.36 (0.09)	1.00 (0.02)	<0.001	1.42 (0.07)	1.00 (0.02)	<0.001
Vegetables (cup eq.)	1.98 (0.07)	1.36 (0.01)	<0.001	2.02 (0.05)	1.42 (0.01)	<0.001
Dark green veg. (cup eq.)	0.31 (0.03)	0.13 (0.01)	<0.001	0.33 (0.02)	0.13 (0.01)	<0.001
Whole grains (ounce eq.)	1.54 (0.10)	0.84 (0.01)	<0.001	1.49 (0.08)	0.84 (0.01)	<0.001
Refined grains (ounce eq.)	5.86 (0.22)	5.67 (0.03)	0.252	5.50 (0.22)	5.68 (0.03)	0.811
Total protein foods (ounce eq.)	6.70 (0.27)	5.73 (0.04)	<0.001	6.50 (0.22)	5.72 (0.04)	0.001
Meat (ounce eq.)	1.02 (0.12)	1.53 (0.02)	<0.001	1.02 (0.10)	1.54 (0.02)	<0.001
Total dairy (cup eq.)	1.69 (0.08)	1.72 (0.02)	0.895	1.68 (0.06)	1.72 (0.02)	0.409
Added sugars (g)	12.2 (0.67)	17.3 (0.16)	<0.001	11.8 (0.52)	17.3 (0.16)	<0.001

[1] Values are presented as means (SE) of two-day intake. NHANES, National Health and Nutrition Examination Survey; [2] p-value for the difference in means across consumers and non-consumers, adjusted for age, gender, and poverty-to-income ratio.

3.3. Health Outcomes in Hummus and Chickpea Consumers Versus Non-Consumers

There were some observable differences in dietary biomarkers across hummus and chickpea non-consumers and consumers (Table 4). Hummus and chickpea consumers had lower concentrations of urinary iodine and higher concentrations of serum 4-pyridoxic acid, total vitamin B_6, and red blood cell folate. There were no significant differences in serum concentrations of pyridoxal 5′-phosphate, vitamin B_{12}, vitamin D ($25OHD_2$, $25OHD_3$, and $25OHD_2 + 25OHD_3$), copper, selenium, or zinc.

Table 4. Consumption of fruits, vegetables, whole grains, and added sugars in hummus and chickpea consumers and non-consumers in U.S. children and adults, NHANES 2005–2016 [1].

Dietary Biomarker	Available Data Releases	Hummus			Chickpea		
		Consumers	Non-Consumers	p [2]	Consumers	Non-Consumers	p
Serum							
Pyridoxal 5′-phosphate (nmol/L) [3]	2005–2010	74.8 (1.1)	52.1 (1.0)	<0.001	71.4 (1.1)	52.0 (1.0)	0.001
4-pyridoxic acid (nmol/L) [3]	2005–2010	40.5 (1.1)	30.7 (1.0)	0.143	39.5 (1.1)	30.7 (1.0)	0.146
Vitamin B_6: pyridoxal 5′-phosphate + 4-pyridoxic acid (nmol/L) [3]	2005–2010	121 (1.1)	87.2 (1.0)	0.014	117 (1.1)	87.1 (1.1)	0.016
Vitamin B_{12} (pg/mL)	2005–2006, 2011–2012	528 (1.1)	513 (1.0)	0.643	515 (1.1)	513 (1.1)	0.952
Vitamin D (nmol/L)							
$25OHD_2$	2009–2016	3.67 (0.7)	3.41 (0.1)	0.985	3.33 (0.5)	3.42 (0.1)	0.445
$25OHD_3$	2009–2016	72.9 (2.3)	66.0 (0.8)	0.106	71.2 (1.9)	66.0 (0.8)	0.258
$25OHD_2 + 25OHD_3$	2009–2016	76.6 (2.3)	69.4 (0.7)	0.102	74.5 (1.9)	69.4 (0.7)	0.353
Red blood cell folate	2005–2016	529 (15.2)	490 (4.7)	0.039	529 (12.1)	489.5 (4.7)	0.018
Copper (µg/dL)	2011–2016	113 (3.8)	117 (0.7)	0.052	115 (3.5)	117 (0.7)	0.120
Selenium (µg/L)	2011–2016	129 (2.3)	129 (0.6)	0.789	130 (2.0)	129 (0.6)	0.558
Zinc (µg/dL)	2011–2016	80.6 (1.9)	82.2 (0.5)	0.509	80.6 (1.6)	82.2 (0.5)	0.451
Urine							
Iodine (ng/mL) [3]	2005–2016	97.0 (1.1)	146 (1.0)	0.008	104 (1.1)	146 (1.0)	0.003

[1] Values are presented as means (SE) unless indicated otherwise. Numbers of consumers and non-consumers are not reported because varies by biomarker availability in a particular data release (see *Materials and Methods*). NHANES, National Health and Nutrition Examination Survey; [2] p-values for the difference in means across consumers and non-consumers, adjusted for age, gender, and poverty-to-income ratio; [3] Geometric means.

There were no significant differences in body weight across hummus and chickpea consumers and non-consumers (Table 5). However, hummus and chickpea consumers had significantly lower BMI and waist circumference than non-consumers, after adjustment for age, gender, and PIR. MetS could only be classified in adults. A lower percentage of hummus consumers (either day) had MetS (n = 13, 7.0%), compared to hummus non-consumers (n = 2742, 20.2%). After adjustment for age, gender, and PIR, hummus consumers were 62% less likely to be classified as having MetS (OR = 0.38 [95% CI, 0.16, 0.88]). A lower percentage of chickpea consumers (either day) had MetS (n = 33, 9.8%) compared to chickpea non-consumers (n = 2721, 20.2%). After adjustment for age, gender, and PIR, chickpea consumers were 48% less likely to be classified as having MetS (OR = 0.52 [95% CI, 0.31, 0.89]).

Table 5. Anthropometric measures in hummus and chickpea consumers and non-consumers in U.S. children and adults, aggregated across NHANES 2005–2016. [1]

Anthropometric Measure	Hummus			Chickpea		
	Consumers (n = 392)	Non-Consumers (n = 37,160)	p [2]	Consumers (n = 622)	Non-Consumers (n = 36,930)	p
Weight (kg)	74.0 (1.4)	74.1 (0.3)	0.712	74.7 (1.3)	74.1 (0.3)	0.701
Waist circumference (cm)	90.5 (1.1)	92.4 (0.2)	0.039	91.5 (1.0)	92.3 (0.2)	0.045
Body mass index (kg/m^2)	25.9 (0.4)	27.0 (0.1)	0.013	26.3 (0.4)	27.0 (0.1)	0.015

[1] Values are presented as means (SE) unless indicated otherwise. NHANES, National Health and Nutrition Examination Survey; [2] p-value for the difference in means across consumers and non-consumers, adjusted for age, gender, and poverty-to-income ratio.

4. Discussion

In the current study, we found that hummus and chickpea consumption has increased significantly since the 2005–2006 NHANES; however, overall consumption in the population is low. The finding that hummus, but not chickpea, consumption has increased since the 2005–2006 NHANES among lower-income individuals is not surprising due to the demonstrated limited access to similar items such as fresh produce [25,26]. On the other hand, the minimal food processing techniques involved with extending the shelf life of hummus [27,28] make it a reasonable strategy to increase intake of legumes among lower-income populations. The further observation that consumption of hummus and chickpeas is independently associated with increased intakes of fruits, vegetables, total protein foods, and whole grains (and decreased intake of added sugars) supports consumption to be an effective strategy to increase intakes of other healthful foods in the diet. According to the Produce for Better Health Foundation, recent fruit and vegetable consumption declines are tied to two common behaviors: a decline in dinner side dishes for vegetables, and a reduced consumption of fruit juice at breakfast [29]. Hummus and chickpeas were shown to be mostly consumed at lunch and dinner, as well as during snacking occasions. More than 90% of Americans report two to three snacking occasions throughout the day; snacking provides nearly 23% of total daily energy intakes for most Americans and as much as 35% of total added sugars among children [30]. It is likely that hummus can act as a "carrier" food to help increase diet quality and the intake of more healthful foods such as vegetables and whole grains during snacking and other eating occasions. A recent study in healthy adults supports this observation; an afternoon hummus snack was associated with improved diet quality and a ≈20% decrease in subsequent snacking of desserts [19].

Based on nutrient biomarker analyses, consumers of hummus were more likely to have higher levels of serum 4-pyridoxic acid, total vitamin B_6, and red blood cell folate. We recently showed that serum vitamin B_6 levels decrease with age among middle-aged to older adults [31], indicating a potential need for future observational data that extend beyond the capabilities of NHANES and future public emphasis on foods (or dietary supplements) that contain significant amounts of this essential nutrient. The finding that hummus and chickpea consumers have a lower incidence of MetS and decreased BMI and waist circumference is likely somewhat due to its contribution to intakes of several essential macro- and micronutrients associated with increased diet quality [14]. As supported by the other observations, hummus and chickpea consumption is also likely a marker of healthier diet and lifestyle habits.

A major strength of this study is the use of NHANES, which has a large sample size and is nationally representative. Limitations of NHANES include the sole reliance on self-reported dietary data. A previous validity analysis of the USDA Automated Multiple-Pass Method used for collecting 24-h dietary recalls in the What We Eat in America NHANES component found that overall, obese individuals under-report total daily energy intakes by about 11% compared to <3% among normal-weight individuals [32]. While two days of dietary intake may not capture infrequent hummus or chickpea consumers, the results may more reasonably represent usual or frequent hummus or chickpea consumers. NHANES is a series of cross-sectional surveys and cannot be used to calculate incidence of disease or evaluate changes in individuals, and it is not possible to establish a temporal sequence of associations. However, these results provide an informative foundation about potential roles of hummus and chickpea consumption with cardiometabolic diseases. Future studies incorporating longitudinal designs can be used to evaluate whether chronic disease incidence is reduced by chickpea and hummus consumption through better nutrition or lower MetS incidence. Additionally, while NHANES is designed to be representative of the US population, selection bias can occur based on the individual participation in studies, and it commonly held that healthy individuals participate in population-based health research studies, and there may be some limitations on external validity. However, NHANES is designed to be representative of the US population and is used by the Centers for Disease Control and Prevention to assess health trends in the US population as it provides a reasonable representation of the US population.

5. Conclusions

Consumption of hummus and chickpeas in the United States has increased since the 2005–2006 NHANES. Cross-sectional data indicate that hummus and chickpea consumption may lead to more optimal intakes of fruits, total and dark green vegetables, total protein foods, and whole grains, and lower intakes of meat and added sugars compared to non-consumers, adjusted for age, gender, and PIR. No differences across groups were observed for refined grain or dairy consumption. Consumption in this dataset was also associated with an improved status of serum vitamin B_6 and red blood cell folate and a decreased incidence of MetS.

Author Contributions: Conceptualization, C.L.F. and T.C.W.; methodology, C.L.F. and T.C.W.; formal analysis, C.L.F.; data curation, C.L.F. and T.C.W.; writing—original draft preparation, C.L.F. and T.C.W.; writing—review and editing, C.L.F. and T.C.W.; funding acquisition, T.C.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by an investigator-initiated, unrestricted educational grant from Sabra Dipping Co., LLC.

Conflicts of Interest: T.C.W. has received prior research support from Sabra Dipping Co., LLC. C.L.F. declares no conflict of interest. The sponsor had no role in the study design; the collection, analysis, and interpretation of data; the writing of the manuscript; or the decision where to submit the paper for publication.

References

1. Mitchell:, D.C.; Lawrence, F.R.; Hartman, T.J.; Curran, J.M. Consumption of dry beans, peas, and lentils could improve diet quality in the US population. *J. Am. Diet Assoc.* **2009**, *109*, 909–913. [CrossRef]
2. Mudryj, A.N.; Yu, N.; Hartman, T.J.; Mitchell, D.C.; Lawrence, F.R.; Aukema, H.M. Pulse consumption in Canadian adults influences nutrient intakes. *Br. J. Nutr.* **2012**, *108* (Suppl. 1), S27–S36. [CrossRef]
3. Foster-Powell, K.; Holt, S.H.; Brand-Miller, J.C. International table of glycemic index and glycemic load values: 2002. *Am. J. Clin. Nutr.* **2002**, *76*, 5–56. [CrossRef] [PubMed]
4. U.S. Department of Health and Human Services; U.S. Department of Agriculture. *2005 Dietary Guidelines for Americans*, 6th ed.; USDA: Washington, DC, USA, 2005. Available online: https://health.gov/sites/default/files/2020-01/DGA2005.pdf (accessed on 17 September 2020).
5. U.S. Department of Health and Human Services; U.S. Department of Agriculture. *2015–2020 Dietary Guidelines for Americans*, 8th ed.; USDA: Washington, DC, USA, 2015. Available online: https://health.gov/dietaryguidelines/2015/guidelines/ (accessed on 17 September 2020).
6. Ha, V.; Sievenpiper, J.L.; de Souza, R.J.; Jayalath, V.H.; Mirrahimi, A.; Agarwal, A.; Chiavaroli, L.; Mejia, S.B.; Sacks, F.M.; Di Buono, M.; et al. Effect of dietary pulse intake on established therapeutic lipid targets for cardiovascular risk reduction: A systematic review and meta-analysis of randomized controlled trials. *CMAJ* **2014**, *186*, E252–E262. [CrossRef] [PubMed]

7. Jayalath, V.H.; de Souza, R.J.; Sievenpiper, J.L.; Ha, V.; Chiavaroli, L.; Mirrahimi, A.; Di Buono, M.; Bernstein, A.M.; Leiter, L.A.; Kris-Etherton, P.M.; et al. Effect of dietary pulses on blood pressure: A systematic review and meta-analysis of controlled feeding trials. *Am. J. Hypertens* **2014**, *27*, 56–64. [CrossRef] [PubMed]
8. Kim, S.J.; de Souza, R.J.; Choo, V.L.; Ha, V.; Cozma, A.I.; Chiavaroli, L.; Mirrahimi, A.; Blanco Mejia, S.; Di Buono, M.; Bernstein, A.M.; et al. Effects of dietary pulse consumption on body weight: A systematic review and meta-analysis of randomized controlled trials. *Am. J. Clin. Nutr.* **2016**, *103*, 1213–1223. [CrossRef]
9. Li, S.S.; Kendall, C.W.; de Souza, R.J.; Jayalath, V.H.; Cozma, A.I.; Ha, V.; Mirrahimi, A.; Chiavaroli, L.; Augustin, L.S.; Blanco Mejia, S.; et al. Dietary pulses, satiety and food intake: A systematic review and meta-analysis of acute feeding trials. *Obesity (Silver Spring)* **2014**, *22*, 1773–1780. [CrossRef]
10. Sievenpiper, J.L.; Kendall, C.W.; Esfahani, A.; Wong, J.M.; Carleton, A.J.; Jiang, H.Y.; Bazinet, R.P.; Vidgen, E.; Jenkins, D.J. Effect of non-oil-seed pulses on glycaemic control: A systematic review and meta-analysis of randomised controlled experimental trials in people with and without diabetes. *Diabetologia* **2009**, *52*, 1479–1495. [CrossRef]
11. Afshin, A.; Micha, R.; Khatibzadeh, S.; Mozaffarian, D. Consumption of nuts and legumes and risk of incident ischemic heart disease, stroke, and diabetes: A systematic review and meta-analysis. *Am. J. Clin. Nutr.* **2014**, *100*, 278–288. [CrossRef]
12. Viguiliouk, E.; Blanco Mejia, S.; Kendall, C.W.; Sievenpiper, J.L. Can pulses play a role in improving cardiometabolic health? Evidence from systematic reviews and meta-analyses. *Ann. N. Y. Acad. Sci.* **2017**, *1392*, 43–57. [CrossRef]
13. Wallace, T.C.; Murray, R.; Zelman, K.M. The nutritional value and health benefits of chickpeas and hummus. *Nutrients* **2016**, *8*, 766. [CrossRef] [PubMed]
14. O'Neil, E.; Nicklas, A.; Fulgoni, V.L., III. 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. *Nutr. Food Sci.* **2014**, *4*, 1–8.
15. Statistica. Sales Value of Hummus Worldwide from 2019 to 2024. 2020. Available online: https://www.statista.com/statistics/1077091/global-hummus-market-size/ (accessed on 17 September 2020).
16. Sawant, A. Hummus Market Top Companies Strategy, Value Analysis, Gross Margin, Sales, Global production and consumption by forecast to 2027. 2019. Available online: https://www.abnewswire.com/pressreleases/hummus-market-top-companies-strategy-value-analysis-gross-margin-sales-global-production-and-consumption-by-forecast-to-2027_428095.html (accessed on 21 September 2020).
17. Jukanti, A.K.; Gaur, P.M.; Gowda, C.L.; Chibbar, R.N. Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): A review. *Br. J. Nutr.* **2012**, *108* (Suppl. 1), S11–S26. [CrossRef] [PubMed]
18. De Camargo, A.C.; Favero, B.T.; Morzelle, M.C.; Franchin, M.; Alvarez-Parrilla, E.; de la Rosa, L.A.; Geraldi, M.V.; Maróstica Júnior, M.R.; Shahidi, F.; Schwember, A.R. Is chickpea a potential substitute for soybean? Phenolic bioactives and potential health benefits. *Int. J. Mol. Sci.* **2019**, *20*, 2644. [CrossRef]
19. Papakonstantinou, E.; Orfanakos, N.; Farajian, P.; Kapetanakou, A.E.; Makariti, I.P.; Grivokostopoulos, N.; Ha, M.A.; Skandamis, P.N. Short-term effects of a low glycemic index carob-containing snack on energy intake, satiety, and glycemic response in normal-weight, healthy adults: Results from two randomized trials. *Nutrition* **2017**, *42*, 12–19. [CrossRef]
20. Centers for Disease Control and Prevention. NHANES: Questionnaires, Datasets, and Related Documentation. 2020. Available online: https://wwwn.cdc.gov/nchs/nhanes/Default.aspx (accessed on 17 September 2020).
21. Centers for Disease Control and Prevention. About the National Health and Nutrition Examination Survey. 2017. Available online: https://www.cdc.gov/nchs/nhanes/about_nhanes.htm (accessed on 17 September 2020).
22. Blanton, C.A.; Moshfegh, A.J.; Baer, D.J.; Kretsch, M.J. The USDA Automated Multiple-Pass Method accurately estimates group total energy and nutrient intake. *J. Nutr.* **2006**, *136*, 2594–2599. [CrossRef]
23. U.S. Department of Agriculture Agricultural Research Service. Food Patterns Equivalents Database. 2017. Available online: https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fped-databases/ (accessed on 17 September 2020).
24. National Institutes of Health. National Cholesterol Education Program: ATP III Guidelines At-a-Glance Quick Desk Reference. 2001. Available online: https://www.nhlbi.nih.gov/files/docs/guidelines/atglance.pdf (accessed on 17 September 2020).

25. Hendrickson, D.; Smith, C.; Eikenberry, N. Fruit and vegetable access in four low-income food deserts communities in Minnesota. *Agric. Hum. Val.* **2006**, *23*, 371–383. [CrossRef]
26. Algert, S.J.; Agrawal, A.; Lewis, D.S. Disparities in access to fresh produce in low-income neighborhoods in Los Angeles. *Am. J. Prev. Med.* **2006**, *30*, 365–370. [CrossRef]
27. Ahmed, J.; Thomas, L.; Mulla, M. High-pressure treatment of hummus in selected packaging materials: Influence on texture, rheology, and microstructure. *J. Food Process Eng.* **2020**, *43*, e13425. [CrossRef]
28. Yamani, M.I.; Mehyar, G.F. Effect of chemical preservatives on the shelf life of hummus during different storage temperatures. *Jordan J. Agric. Sci.* **2011**, *173*, 1–26.
29. Produce for Better Health Foundation. State of the Plate: 2015 Study on America's Consumption of Fruit & Vegetables. 2015. Available online: https://fruitsandveggies.org/wp-content/uploads/2019/05/2015-State_of_the_Plate.pdf (accessed on 17 September 2020).
30. Dietary Guidelines Advisory Committee. Scientific Report of the 2020 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Agriculture and the Secretary of Health and Human Services. 2020. Available online: https://www.dietaryguidelines.gov/2020-advisory-committee-report (accessed on 17 September 2020).
31. Wallace, T.C.; Frankenfeld, C.L.; Frei, B.; Shah, A.V.; Yu, C.R.; van Klinken, B.J.; Adeleke, M. Multivitamin/multimineral supplement use is associated with increased micronutrient intakes and biomarkers and decreased prevalence of inadequacies and deficiencies in middle-aged and older adults in the United States. *J. Nutr. Gerontol. Geriatr.* **2019**, *38*, 307–328. [CrossRef] [PubMed]
32. Moshfegh, A.J.; Rhodes, D.G.; Baer, D.J.; Murayi, T.; Clemens, J.C.; Rumpler, W.V.; Paul, D.R.; Sebastian, R.S.; Kuczynski, K.J.; Ingwersen, L.A.; et al. The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. *Am. J. Clin. Nutr.* **2008**, *88*, 324–332. [CrossRef] [PubMed]