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Title

Association of Pasta Consumption with Diet Quality and Nutrients of Public Health Concern in Adults: National Health and Nutrition Examination Survey 2009-2012

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Authors

Victor L. Fulgoni, III, PhD, Senior Vice President, Nutrition Impact, LLC, 9725 D Drive North, Battle Creek, Michigan 49014; tel: 269.962.048; fax: 269.962.0448; e-mail: vic3rd@aol.com

Regan Bailey, PhD, MPH, RD Associate Professor, Department of Nutrition Science, Purdue University, 700 West State Street, West Lafayette, IN 47907; tel**:** 765.494.2829; fax: 765.494.0674; e-mail: reganbailey@purdue.edu

Corresponding and reprint author:

Victor L. Fulgoni, III, PhD, Senior Vice President, Nutrition Impact, LLC, 9725 D Drive North, Battle Creek, Michigan 49014; tel: 269.962.048; fax: 269.962.0448; e-mail: vic3rd@aol.com

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ABSTRACT

Background Pasta is a commonly consumed food in the United States; however, little is known about pasta consumption and nutrient intake and diet quality.

Objective This study examined the association between pasta consumption and diet quality.

Design and participants Cross-sectional data analysis of 10,697 U.S. adults from the National Health and Nutrition Examination Survey (NHANES) 2009-2012, a nationally representative survey.

Main outcome measures Diet quality as assessed by the Healthy Eating Index-2010 (HEI-2010), nutrient intakes, and dietary patterns.

Statistical analyses Cluster analyses was used among pasta consumers to characterize dietary patterns. Regression analyses determined differences between groups.

Results Overall mean diet quality was similar between pasta consumers and non-consumers. However, consumers of “pasta, noodles” had a 5.6% higher HEI-2010 scores; HEI-2010 was 7.9% lower in those who ate “macaroni and cheese (.” All pasta, “pasta/noodles”, and “pasta mixed dishes, excluding macaroni and cheese” (“pasta mixed dishes”) had higher dietary fiber intakes by 11.0-13.6% (range 1.89-2.35 g/day). “Pasta mixed dishes” was associated with a 5% increase in both potassium and sodium intake (about 150 and 190 mg/d, respectively). Cluster analyses identified pasta eating patterns that are associated with both increased and decreased diet quality as compared to non-consumers.

Conclusions Different dietary patterns exist with regard to pasta consumption. These pasta patterns contribute in different ways to diet quality and intakes of fiber, sodium, and potassium. Therefore, it is critical to separate types of pasta/pasta dishes before relating to dietary intakes.

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46 **Keywords:** Diet quality, nutrient intake, National Health and Nutrition Examination Survey

47 (NHANES), Healthy Eating Index (HEI), cluster analysis, pasta

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Pasta is a commonly consumed food in the United States;[1] however, pasta is often used as an umbrella term to describe several types of dishes some of which are considered healthy and others less healthy. Furthermore, very little is known about how pasta contributes to the quality of the American diet or its effects if any, on overweight and obesity. When pasta is cooked correctly (al dente) it can have a low glycemic index,[2] may possibly slow digestion rates[3] and may contribute to longer satiety.[5]4and when consumed with tomato products provides a high source of dietary lycopene.[5] Increasing epidemiological evidence has also associated the consumption of foods rich in phytochemicals (e.g., fruits, vegetables, and whole grains), often consumed in combination with pasta, to reduced incidence of cardiovascular disease, obesity, diabetes, cancer, and other chronic degenerative diseases,[6,7] yet there are few epidemiological data on pasta/pasta containing foods contributions to nutrient intake and diet quality.

Therefore, the purpose of this analysis was to use data from the National Health and Nutrition Examination Survey (NHANES) 2009-2012[8] to determine the associations between pasta consumption and nutrient intake, with a focus on the nutrients of public health concern as identified by the 2015-2020 Dietary Guidelines for Americans (DGA)[1], diet quality, and dietary patterns of pasta consumers.

METHODS

Study Population

The NHANES is a series of cross-sectional surveys of noninstitutionalized, civilian U.S. resident population conducted to assess the health and nutrition status of U.S. population. The study population was limited to adult participants ≥19 years of age (n=10,697) participating in the 2009-2010 and 2011-2012 NHANES with reliable 24-hour recall dietary interview data (as

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defined by USDA staff) and excluded pregnant or lactating females (n=170). The data from the two NHANES cycles were merged to increase sample size. Complete details of NHANES study design, implementation, datasets, analytic considerations, and other documentation are available online.[9-12] The Research Ethics Review Board at the National Center for Health Statistics approved the NHANES survey protocol and all participants and proxies provided written informed consent;[13] as this was a secondary data analysis that lacked personal identifiers additional institutional review as not necessary.

NHANES combines an in home interview with a physical examination.[8] Participants are administered a series of detailed questionnaires at an in-home interview, followed by a visit to a Mobile Examination Center (MEC). There they undergo health examinations and an in-person dietary interview known as the What We Eat in America (WWEIA)[14] component of the NHANES. At the MEC dietary interview, a set of three-dimensional food models are available for participants to use when reporting amounts of foods.[14] A second dietary recall interview is collected by telephone 3 to 10 days following the MEC interview.[14] Demographic data (including age, gender, race/ethnicity, poverty income ratio [PIR], physical activity, smoking status, and alcohol intake) were collected during household interview. PIR is a measure that represents the ratio of household income to the poverty threshold after adjustments for geographic location and family size, developed by the Department of Health and Human Services. A PIR value <1.00 indicates that a family is below the official poverty threshold. Physical activity was classified as sedentary, moderate activity, or active based on self-report. Participants who reported “7 days active at least 60 minutes in the past 7 days” or gave a positive response to two questions about vigorous recreational or work-related activity were considered active. Moderately active participants reported between 4 and 6 “days active at least 60 minutes

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in the past 7 days" or gave a positive response to two questions on moderate recreational or work-related activity. All other participants were classified as sedentary.[15]

WWEIA data are collected using USDA's Automated Multiple-Pass Method (AMPM), [16] a fully computerized method for collecting 24-hour dietary recalls either in person or by telephone. Each of the food and beverage items reported in WWEIA are categorized by USDA into one of 6 mutually exclusive food categories (i.e., milk and dairy, protein foods, mixed dishes, grains, snacks and sweets, and fruit). This is done by linking each food code contained in the Food and Nutrient Database for Dietary Studies (FNDDS) [17] to one WWEIA category. A new version of the FNDDS is produced for each 2-year release cycle of WWEIA.[18]

The focus of the food categorization system is on grouping similar foods and beverages together based on usage and nutrient content. This classification scheme includes approximately 150 unique food sub-categories. Each sub-category is assigned a 4-digit number and description and each FNDDS food code is linked to a unique sub-category. Sub-categories contain discrete food items with no disaggregation into ingredients (e.g., pizza is reported as pizza vs. its components grain, cheese, and tomatoes).[19]

USDA pasta food categories includes cooked grains and grain-based mixed dishes. The specific food sub-categories used to define pasta for this analysis were "pasta, noodles, and cooked grains" ("pasta/noodles"; food category 4004), excluding cooked grains (barley, millet, bulgur, etc.) and "pasta mixed dishes, excluding macaroni and cheese" ("pasta mixed dishes": food category 3204), and "macaroni and cheese;" food category 3206) from mixed dishes.[19] Subjects were classified as pasta consumers or non-consumers based on the first 24-hr dietary recall, having consumed "pasta/noodles", "pasta mixed dishes", and/or "macaroni and cheese" (i.e., pasta consumers). Total daily energy and six nutrients of public health concern (saturated

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fat, dietary fiber, calcium, sodium, potassium and vitamin D) [1] were determined for all participants. Overall diet quality was assessed by the Healthy Eating Index – 2010 (HEI-2010)[20,22] which employs a scoring metric that assesses adherence to the Dietary Guidelines for Americans.[1] HEI-2010 is made up of 12 components; nine of them assess dietary adequacy (total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acid ratio) while three assess dietary components that should be consumed in moderation (refined grains, sodium, and empty calories [energy from solid fats, alcohol, and added sugars - SOFAAS]). Higher intake of adequacy components and lower intake of moderation components indicate better compliance with the DGA[1] and lead to higher scores. The total 2010 HEI[22] is the sum of the component scores and is a measure of overall diet quality; the highest quality score is 100 points and has been extensively validated[23] and was calculated on an individual subject basis.

Statistical Analysis

All analyses were adjusted for the complex sample design of NHANES and used appropriate sample-weights. Analyses were performed with SAS (version 9.2, 2010, SAS Institute, Inc., Cary, NC) and SUDAAN (version 11.01, 2014, Research Triangle Institute, Durham, NC).

Regression analyses of intakes from the first-day dietary recall were conducted to assess differences between pasta consumers and non-consumers and for the three specific food sub-categories of pasta: “pasta/noodles”, “pasta mixed dishes” and “macaroni and cheese”. Analyses of energy intake, total HEI-2010 scores, and subcomponent scores included covariate

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adjustments for age, gender, race/ethnicity, PIR, physical activity level, smoking status, and alcohol intake. Energy intake was an additional covariate in analyses of all nutrients.

Additionally, SAS Proc Cluster was used to categorize dietary patterns of pasta consumers based on food group intakes as defined by the USDA Food Patterns Equivalent Database.[24] Food group intakes were standardized to z-scores prior to cluster analyses. Non-consumers were classified as cluster 0. The identified food group intakes associated with clusters were deemed meaningful if individual food group categories were at least 40% different from non-consumers (which was about twice the average difference of a key food groups, i.e., fruit intake). HEI 2010 scores by cluster groups were compared using regression analyses and t-tests. For all analyses, $p<0.05$ was considered statistically significant.

RESULTS

A total of 1,487 (14.7%) of adults consumed pasta on the Day 1 recall. Overall, pasta consumers were more likely to be females, younger, and less likely to be Hispanic (**Table 1**). Consumers of "pasta mixed dishes" (n=877, 8.9%) were more likely to be female, non-Hispanic White, and less likely to be Hispanic than non-consumers while consumers of "macaroni and cheese" (n=406, 3.7%) were more likely to be female, younger, non-Hispanic Black, have an income ≤1.3 PIR, and less likely to be Hispanic and sedentary as compared to non-consumers (Table 1). Those consuming "pasta/noodles" (n=232, 2.4%), were less likely to be Hispanic, non-Hispanic Black or current smokers (Table 1).

In fully-adjusted models, energy intake was higher (difference ± SE: 170 ± 41 kcal/d) in pasta consumers as compared to non-consumers (**Table 2**) and was also higher in consumers of

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"pasta mixed dishes" (169 ± 44 kcal/d) and "macaroni and cheese" (267 ± 56 kcal/d) but not "pasta/noodles" as compared to non-consumers. Total saturated fatty acids were only higher (5.5 ± 1.1 g/d) in consumers of "macaroni and cheese" as compared to non-consumers. Mean dietary fiber intake was higher (1.9 ± 0.3 g/d) among all pasta consumers than non-consumers. Similarly, those who consumed "pasta mixed dishes" (2.3 ± 0.4 g/d) and those who ate "pasta/noodles" (2.3 ± 0.9 g/d) had higher fiber intakes than non-consumers of these pasta groups. Relatively few differences in intakes of calcium, potassium, sodium and vitamin D were observed regardless of pasta consumption group. However, mean potassium and sodium intake was significantly higher (149 ± 60 and 187 ± 69 mg/d, respectively), and vitamin D intake was significantly lower (-0.7 ± 0.2 µg/d) in consumers of "pasta mixed dishes" as compared with non-consumers.

Overall, there was no significant difference in diet quality (HEI-2010 scores: 49.9±0.6 vs. 51.0±0.3) between pasta consumers and non-consumers, (**Table 3**). No overall differences in HEI-2010 (49.9±0.8 vs. 50.9±0.3) were seen in the "pasta mixed dishes" pasta group as compared to non-consumers. Consumers of "macaroni and cheese" had a significantly lower mean HEI-2010 score (46.9±1.0 vs. 51.0±0.3) compared to non-consumers, mainly driven by differences in females (47.9±0.3 vs. 52.3±0.4, p=0.001). Consumers of "pasta/noodles" had a higher total mean HEI-2010 score (53.6±0.3 vs. 50.7±1.4) as compared with non-consumers. The HEI sub-components that accounted for the lower HEI-2010 total score in "macaroni and cheese" consumers were SOFAAS calorie (-2.1 point), total vegetables (-0.7 point), refined grains (-0.7 point), whole grains (-0.7 point), fatty acid ratio (-0.7 point), and total fruit (-0.4 point) which were partially offset by improvements in sodium (+1.0 point) and dairy (+0.6 point) sub-components. The HEI sub-components that accounted for the higher HEI-2010 total score in

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"pasta/noodles" consumers were SOFAAS calories (+2.8 points) which was partially offset by lower scores for dairy (-0.9 points) and refined grain (-0.7 points) sub-components.

Dietary patterns identified three distinct pasta consumption groups (**Table 4**). Using differences +/- 40% or more of that of non-consumers (cluster 0), cluster 1 (n=811) represented about 8% of the total population and can be described as having lower intakes of fruit, fish, whole grains and higher intakes of refined grains as compared to pasta non-consumers. Cluster 2 (n=419) represented about 4% of the total population and can be described as having higher intakes of fruit and other (non-animal) protein and lower intakes of meat, poultry, and fish while cluster 3 (n=257) represented about 2.5% of the total population and can be described as having higher intakes of fruit, vegetables, fish, other (non-animal) protein, and less meat as compared to pasta non-consumers. The total HEI-2010 score was higher in cluster 2 and cluster 3 (2.8 and 10.6 points, respectively) than in non-consumers (**Table 5**). Cluster 1 HEI-2010 scores were lower (-7.2 points) as compared to non-consumers.

DISCUSSION

This is one of the few epidemiological studies national in scope that has investigated the association between types and patterns of pasta consumption with nutrient intakes and diet quality. Our findings suggest that when considering all types of pasta (i.e., grouped together), consumption was not associated with diet quality. However, specific types of pasta were associated with changes in HEI 2010. "pasta/noodles" consumption was associated with a slightly improved diet quality while consumption of "macaroni and cheese" was associated with lower diet quality. Only "pasta/noodles" was not associated with higher daily calories, while

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"pasta mixed dishes" and "pasta/noodles" were associated with increased dietary fiber intake. "Pasta mixed dishes" was also associated with higher intakes of potassium and sodium. Cluster analyses showed that among pasta consumers, there can be quite divergent dietary patterns. In this study Cluster 1 had the lowest HEI-2010 score (-7.2 points as compared to non-consumers) while Cluster 3 had the highest HEI-2010 score (10.6 points higher than non-consumers) thus the difference between these two patterns was almost 18 points and Cluster 3 had about 40% improvement over Cluster 1 HEI scores. The cluster 3 pattern, with more fruit, vegetables, fish, whole grains and less meat is very similar to the Healthy Mediterranean Style and the Dietary Approaches to Stop Hypertension (DASH) eating pattern as described in the 2015-2020 DGA[1] and as such these improvements in diet quality makes sense. Unfortunately only about 2.5% of the adult population was consuming Cluster 3 type pattern. A concerted effort from health professionals and food manufactures to help consumers better combine healthier foods/food forms with their favorite pasta dishes is needed. Simultaneously, given almost 8% of the adult population are consuming pasta in ways that are associated with a reduction in diet quality, efforts should be undertaken to find ways to educate consumers that there are better ways to enjoy pasta (like that in cluster 3). Consideration should also be given to develop "macaroni and cheese" recipes that are more consistent with current dietary recommendations, especially reducing saturated fat. Additionally, development of lower sodium versions of "pasta mixed dishes", while retaining sources of potassium, would also be helpful.

This study has limitations inherent in all observational research. Data for energy and nutrient intakes, including food group intakes used to determine diet quality, were obtained using 24-hour dietary recalls, which rely on self-report and may not always represent typical intake. Given we

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used the first day of dietary recalls our results indicate what may occur on any given day. While validated procedures were used to collect the data, recalled information may have inaccuracies and biases from misreporting, memory lapses, and other potential measurement errors that occur in epidemiological research involving large datasets[25]. In addition, given current evidence is observational, a causal link between intake of pasta and improvements in diet quality and nutrient intakes cannot be established. We were also not able to analyze whether there were differences due to whole grain versus non-whole grain pasta due to very limited reports of whole grain pasta consumption. Numerous covariates were used to adjust data in an attempt to remove potential confounding, but there could still be residual confounding. Cluster analysis also has some disadvantages as it groups individuals who may identify with multiple dietary patterns. [26]

Nevertheless, the results from this large, nationally-representative study suggest that the type of pasta consumed and other foods consumed with pasta can impact diet quality and intake of key nutrients of public health concern. Consumption of pastas and noodles was associated with a small increase in diet quality and fiber intake while consumption of “macaroni and cheese” was associated with a lower diet quality and higher saturated fat intake. Cluster analyses indicated that there are quite divergent dietary patterns among American pasta consumers and one pattern, closely aligned to the Healthy Mediterranean Style eating pattern, can led to large improvements in diet quality. This work highlights the need to meaningfully separate major food groups/sub-groups before making associations with diet quality and nutrient intakes.

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Statement of authors' contributions to manuscript: VF developed original project concept and initial research plan and RB added to research plan; VF analyzed data and performed statistical testing; VF and RB had significant input in manuscript development and both read and approved the final version.

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Table 1. Demographics of Adult (19+ years) Pasta Consumers and Non-consumers[1]

Variable	Non-consumer Mean±SE	Consumer Mean±SE
	All Pasta[2]	
n	9,210	1,487
Age, years	47.20±0.50	44.86±1.03*
Gender = Male (%)	50.32±0.61	44.05±1.70*
Ethnicity = Hispanic (%)	14.99±1.99	7.90±1.08*
Ethnicity = Non-Hispanic White (%)	66.77±2.60	71.41±2.61
Ethnicity = Non-Hispanic Black (%)	11.43±1.27	12.76±1.80
PIR <= 1.3 (%)	24.38±1.32	25.36±1.97
1.3 < PIR < 1.85 (%)	10.20±0.55	10.75±1.02
PIR >= 1.85 (%)	65.41±1.61	63.88±2.32
Physical Activity = Sedentary (%)	21.87±0.96	21.43±1.69
Physical Activity = Moderate (%)	39.50±0.76	38.64±1.68
Physical Activity = Vigorous (%)	38.62±1.35	39.93±2.32
Smoking Current (%)	20.97±0.93	21.57±1.98
BMI, kg/m^2	28.70±0.11	28.52±0.33
	Pasta mixed dishes (excludes macaroni and cheese)	
n	9,820	877
Age, years	46.92±0.52	46.20±1.19
Gender = Male (%)	49.87±0.60	44.61±2.28*
Ethnicity = Hispanic (%)	14.42±1.89	9.11±1.48*
Ethnicity = Non-Hispanic White (%)	66.78±2.58	74.34±2.85*
Ethnicity = Non-Hispanic Black (%)	11.72±1.33	10.67±1.49
PIR <= 1.3 (%)	24.67±1.24	23.14±2.75
1.3 < PIR < 1.85 (%)	10.24±0.57	10.73±1.63
PIR >= 1.85 (%)	65.09±1.56	66.13±3.25
Physical Activity = Sedentary (%)	21.67±0.97	23.18±2.09
Physical Activity = Moderate (%)	39.71±0.79	35.99±1.77
Physical Activity = Vigorous (%)	38.62±1.44	40.83±2.15
Smoking Current (%)	21.01±0.88	21.60±3.37
BMI,kg/m^2	28.72±0.12	28.22±0.29
	Macaroni and cheese	
n	10,291	406
Age, years	47.09±0.53	40.69±1.31*
Gender = Male (%)	49.73±0.59	40.79±2.40*
Ethnicity = Hispanic (%)	14.22±1.88	7.00±1.41*
Ethnicity = Non-Hispanic White (%)	67.46±2.54	67.10±4.50
Ethnicity = Non-Hispanic Black (%)	11.22±1.25	22.00±4.25*

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PIR <= 1.3 (%)	24.14±1.27	34.22±4.38*
1.3 < PIR < 1.85 (%)	10.21±0.53	12.17±2.17
PIR >= 1.85 (%)	65.65±1.59	53.62±5.49*
Physical Activity = Sedentary (%)	22.01±0.98	16.52±2.53*
Physical Activity = Moderate (%)	39.30±0.74	41.38±3.96
Physical Activity = Vigorous (%)	38.69±1.34	42.10±5.10
Smoking Current (%)	20.81±0.89	27.45±3.34
BMI, kg/m^2	28.64±0.12	29.46±0.45
	Pasta, noodles, and cooked grains (except non-pasta grains)	
n	10,465	232
Age, years	46.89±0.53	45.49±1.45
Gender = Male (%)	49.50±0.62	45.22±3.84
Ethnicity = Hispanic (%)	14.19±1.85	4.21±1.14*
Ethnicity = Non-Hispanic White (%)	67.43±2.58	68.15±3.90
Ethnicity = Non-Hispanic Black (%)	11.76±1.33	6.15±1.35*
PIR <= 1.3 (%)	24.64±1.33	20.16±3.49
1.3 < PIR < 1.85 (%)	10.32±0.56	8.71±2.39
PIR >= 1.85 (%)	65.04±1.64	71.13±4.09
Physical Activity = Sedentary (%)	21.80±0.94	22.29±4.83
Physical Activity = Moderate (%)	39.27±0.74	43.79±4.34
Physical Activity = Vigorous (%)	38.93±1.36	33.92±5.23
Smoking Current (%)	21.27±0.84	12.31±2.79*
BMI, kg/m^2	28.68±0.11	28.29±1.13

[1]Data from NHANES 2009-2012, n=10,697 adults 19+ years of age.
[2]All Pasta includes all three types of pasta.
*Significantly different, $p<0.05$ as determined by regression analyses comparing consumers and non-consumers.

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Table 2. Energy and Selected Nutreint Intakes Associated with Pasta Consumption[1]

Variable	Non-consumer LSM[2]±SE[3]	Consumer LSM±SE
All Pasta		
n	9,210	1,487
Energy (kcal)	2144±12	2314±37*
Total saturated fatty acids (gm)	26.1±0.3	27.4±0.7
Sodium (mg)	3583±22	3738±67
Dietary fiber (gm)	17.3±0.2	19.2±0.3*
Calcium (mg)	1004±9	1013±25
Potassium (mg)	2777±18	2826±68
Vitamin D (D2 + D3) (µg)	4.9±0.1	4.7±0.2
Pasta Mixed Dishes (excludes macaroni and cheese)		
n	9,820	877
Energy (kcal)	2154±11	2323±42*
Total saturated fatty acids (gm)	26.3±0.3	26.7±0.8
Sodium (mg)	3589±19	3775±58*
Dietary fiber (gm)	17.3±0.2	19.7±0.4*
Calcium (mg)	1005±8	1009±29
Potassium (mg)	2771±18	2920±65*
Vitamin D (D2 + D3) (µg)	5.0±0.1	4.3±0.2*
Macaroni and Cheese)		
n	10,291	406
Energy (kcal)	2159±12	2426±54*
Total saturated fatty acids (gm)	26.1±0.3	31.6±1.1*
Sodium (mg)	3600±17	3748±117
Dietary fiber (gm)	17.6±0.2	17.4±0.6
Calcium (mg)	1002±8	1077±45
Potassium (mg)	2789±19	2654±118
Vitamin D (D2 + D3) (µg)	4.9±0.1	5.7±0.4
Pasta, noodles, and cooked grains (excluding cooked grains)		
n	10,465	232
Energy (kcal)	2170±11	2134±70
Total saturated fatty acids (gm)	26.4±0.3	24.2±1.4
Sodium (mg)	3604±16	3663±138
Dietary fiber (gm)	17.5±0.2	19.8±0.9*
Calcium (mg)	1007±7	933±50
Potassium (mg)	2785±19	2726±98

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Vitamin D (D2 + D3) (µg)	4.9±0.1	4.6±0.5

[1] Data from NHANES 2009-2012, n=10,697 adults 19+ years of age
[2] LSM: Least square mean
[3] SE: Standard error

*Significantly different, $p<0.05$ as determined by regression analyses comparing consumers and non-consumers adjusting for age, gender, race/ethnicity, poverty income ratio, physical activity level, current smoking status, alcohol intake and energy intake (except for energy).

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Table 3. Healthy Eating Index - 2010 Scores Associated with Pasta Consumption[1]

Variable	Non-consumer LSM[2]±SE[3]	Consumer LSM±SE
All Pasta		
n	9,210	1,487
HEI-2010 total score	50.96±0.34	49.90±0.63
HEI-2010 component 1 (total vegetables)	3.06±0.03	3.07±0.05
HEI-2010 component 2 (greens and beans)	1.32±0.03	1.21±0.08
HEI-2010 component 3 (total fruit)	2.19±0.04	2.11±0.09
HEI-2010 component 4 (whole fruit)	2.14±0.04	2.09±0.12
HEI-2010 component 5 (whole grains)	2.68±0.07	2.38±0.13*
HEI-2010 component 6 (dairy)	5.20±0.06	5.24±0.15
HEI-2010 component 7 (total protein foods)	4.27±0.02	3.81±0.06*
HEI-2010 component 8 (seafood and plant protein)	2.10±0.04	1.95±0.08
HEI-2010 component 9 (fatty acid ratio)	5.16±0.07	5.10±0.12
HEI-2010 component 10 (sodium)	4.19±0.06	4.52±0.12*
HEI-2010 component 11 (refined grains)	6.35±0.06	5.16±0.14*
HEI-2010 component 12 (SOFAAS calories)	12.32±0.15	13.26±0.28*
Pasta Mixed Dishes (excludes macaroni and cheese)		
n	9,820	877
HEI-2010 total score	50.89±0.34	49.91±0.83
HEI-2010 component 1 (total vegetables)	3.03±0.03	3.33±0.07*
HEI-2010 component 2 (greens and beans)	1.32±0.04	1.10±0.09*
HEI-2010 component 3 (total fruit)	2.18±0.04	2.16±0.10
HEI-2010 component 4 (whole fruit)	2.14±0.04	2.04±0.14
HEI-2010 component 5 (whole grains)	2.67±0.07	2.32±0.15*
HEI-2010 component 6 (dairy)	5.20±0.06	5.24±0.20
HEI-2010 component 7 (total protein foods)	4.26±0.02	3.61±0.08*
HEI-2010 component 8 (seafood and plant protein)	2.11±0.04	1.79±0.10*
HEI-2010 component 9 (fatty acid ratio)	5.14±0.07	5.20±0.18
HEI-2010 component 10 (sodium)	4.22±0.06	4.38±0.16
HEI-2010 component 11 (refined grains)	6.30±0.07	4.86±0.16*
HEI-2010 component 12 (SOFAAS calories)	12.32±0.16	13.89±0.33*
Macaroni and Cheese		
n	10,291	406
HEI-2010 total score	50.95±0.33	46.93±0.99*
HEI-2010 component 1 (total vegetables)	3.08±0.03	2.37±0.12*
HEI-2010 component 2 (greens and beans)	1.30±0.04	1.27±0.13
HEI-2010 component 3 (total fruit)	2.19±0.04	1.81±0.13*
HEI-2010 component 4 (whole fruit)	2.14±0.04	1.91±0.14
HEI-2010 component 5 (whole grains)	2.66±0.07	2.02±0.19*
HEI-2010 component 6 (dairy)	5.18±0.06	5.80±0.25*
HEI-2010 component 7 (total protein foods)	4.21±0.02	4.01±0.10
HEI-2010 component 8 (seafood and plant protein)	2.08±0.04	2.12±0.10

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HEI-2010 component 9 (fatty acid ratio)	5.17±0.07	4.52±0.20*
HEI-2010 component 10 (sodium)	4.20±0.06	5.18±0.25*
HEI-2010 component 11 (refined grains)	6.20±0.06	5.54±0.23*
HEI-2010 component 12 (SOFAAS calories)	12.54±0.15	10.39±0.43*
Pasta, noodles, and cooked grains (excluding cooked grains)		
n	10,465	232
HEI-2010 total score	50.74±0.33	53.58±1.37*
HEI-2010 component 1 (total vegetables)	3.06±0.03	3.11±0.11
HEI-2010 component 2 (greens and beans)	1.29±0.04	1.60±0.33
HEI-2010 component 3 (total fruit)	2.18±0.04	2.28±0.22
HEI-2010 component 4 (whole fruit)	2.12±0.04	2.43±0.29
HEI-2010 component 5 (whole grains)	2.63±0.07	3.03±0.38
HEI-2010 component 6 (dairy)	5.22±0.05	4.32±0.29*
HEI-2010 component 7 (total protein foods)	4.20±0.02	4.24±0.10
HEI-2010 component 8 (seafood and plant protein)	2.07±0.04	2.35±0.20
HEI-2010 component 9 (fatty acid ratio)	5.14±0.06	5.67±0.32
HEI-2010 component 10 (sodium)	4.25±0.05	3.92±0.27
HEI-2010 component 11 (refined grains)	6.19±0.06	5.51±0.26*
HEI-2010 component 12 (SOFAAS calories)	12.39±0.15	15.14±0.57*

[1] Data from NHANES 2009-2012, n=10,697 adults 19+ years of age
[2] LSM: Least square mean
[3] SE: Standard error

*Significantly different, $p<0.05$ as determined by regression analyses comparing consumers and non-consumers adjusting for age, gender, race/ethnicity, poverty income ratio, physical activity level, current smoking status, and alcohol intake.

Table 4. Food group Intake Associated with Cluster Analyses of Pasta Consumers[1]

Cluster[2]	N	Pop. Pct.[3]	Food Group Intakes								
			Fruits (cup eq)	Vegetables (cup eq)	Meat (oz eq)	Poultry (oz eq)	Fish (oz eq)	Other Protein (oz eq)	Dairy (cup eq)	Refined Grain (oz eq)	Whole Grain (oz eq)
0	9,210	85.30	1.02	1.60	1.72	1.51	0.68	2.46	1.67	5.59	0.92
1	811	8.02	***0.53***	1.69	2.38	1.53	***0.20***	1.97	1.89	7.97	***0.38***
2	419	4.12	**1.68**	1.21	***0.79***	***0.71***	***0.25***	***1.03***	1.11	5.00	0.85
3	257	2.55	**1.48**	**2.36**	***0.73***	1.20	**1.90**	**4.15**	**2.40**	6.48	**2.27**

[1] Data from NHANES 2009-2012, n=10,697 adults 19+ years of age
[2] Cluster analyses was performed among pasta consumers (non-consumers defined as cluster 0); clusters developed with standardized z-scores of food group intakes
[3]Pop. Pct.: Population percentage; sample weighted population percentage of adults in each cluster
Bolded values are ≥40% higher and bolded and italicized values ≥40% lower than cluster 0 group (non-consumers)

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Table 5. Healthy Eating Index - 2010 Scores Associated with Clusters[1,2]

Description	Cluster 0 Mean±SE	Cluster 1 Mean±SE	Cluster 2 Mean±SE	Cluster 3 Mean±SE
HEI-2010 total score	50.99±0.31[a]	43.80±0.58[b]	53.83±0.90[c]	61.60±1.04[d]
HEI-2010 component 1 (total vegetables)	3.06±0.03	2.96±0.08	3.12±0.11	3.21±0.13
HEI-2010 component 2 (greens and beans)	1.32±0.03[a,c]	1.06±0.09[b]	1.05±0.12[b]	1.81±0.26[c]
HEI-2010 component 3 (total fruit)	2.20±0.03[a]	1.28±0.09[b]	3.33±0.12[c]	2.55±0.18[d]
HEI-2010 component 4 (whole fruit)	2.15±0.04[a]	1.38±0.10[b]	2.96±0.23[c]	2.67±0.23[c]
HEI-2010 component 5 (whole grains)	2.68±0.08[a]	1.10±0.10[b]	3.42±0.25[c]	4.84±0.30[d]
HEI-2010 component 6 (dairy)	5.19±0.07	5.31±0.18	5.04±0.21	5.58±0.33
HEI-2010 component 7 (total protein foods)	4.27±0.02[a]	3.97±0.08[b]	3.15±0.15[c]	4.24±0.09[a]
HEI-2010 component 8 (seafood and plant protein)	2.10±0.04[a]	1.49±0.08[b]	1.70±0.15[c]	3.81±0.15[d]
HEI-2010 component 9 (fatty acid ratio)	5.16±0.07[a]	4.66±0.13[b]	5.17±0.30[a,b]	6.24±0.27[c]
HEI-2010 component 10 (sodium)	4.19±0.06[a]	4.22±0.14[a]	5.00±0.30[b]	4.63±0.26[a,b]
HEI-2010 component 11 (refined grains)	6.33±0.07[a]	4.74±0.20[b]	4.88±0.22[c]	7.31±0.29[d]
HEI-2010 component 12 (SOFAAS[3] calories)	12.35±0.15[a]	11.62±0.35[a]	15.01±0.45[b]	14.71±0.32[b]

[1] Data from NHANES 2009-2012, n=10,697 adults 19+ years of age

[2] Cluster analyses was performed among pasta consumers (non-consumers defined as cluster 0); clusters developed with standardized z-scores of food group intakes

[3] SOFAAS: solid fat, alcohol, and added sugars

[a,b,c,d] Values with different superscrpts are significantly different, $p<0.05$ from regression analyses comparing clusters

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