ORIGINAL RESEARCH

CURRENT DEVELOPMENTS IN NUTRITION

Nutritional Epidemiology and Public Health

Diet Quality and Food Intakes samong US Adults by Level of Animal Protein Intake, What We Eat in America, NHANES 2015–2018

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ABSTRACT

Background: Dietary recommendations encourage consuming protein from a variety of plant and animal sources. Evaluating the diet of US adults by level of animal protein (AP) intake can inform dietary assessment and nutrition education.

Objectives: The objective of this cross-sectional study was to estimate percentage of total protein intake from animal sources by US adults to compare diet quality, and intake from USDA Food Patterns (FP) groups by quintiles of AP.

Methods: One day dietary intake data from adults 20+ y (N = 9566) in What We Eat in America (WWEIA), NHANES 2015–2018 were used. Proportions of total protein intake from animal and plant sources and the USDA FP groups were estimated from the ingredients in the Food and Nutrient Database for Dietary Studies 2015–2018, then applied to the dietary intakes. The 2015 Healthy Eating Index (HEI) was used as an indicator of diet quality. The USDA FP groups were used to describe the contribution of animal and plant foods to total protein intake. Data were analyzed by quintile (Q) of AP protein intake; comparisons were made using pairwise t-tests with adjustments for covariates using survey sample weights. Results were considered significant at $P < 0.001$.

Results: Total mean protein intakes ranged from 62 (Q1) to 104 g (Q5) (all comparisons $P < 0.001$). Total HEI score (possible 100) of Q1 was slightly higher (54.2) ($P < 0.001$) compared with Q1–Q4 (range: 48.0–50.3), which did not differ significantly from each other. Contributions of plant FP components to total protein intake of Q1 to Q5, respectively, were 15% to 1% from nuts/seeds, legumes, and soy products combined; 35 to 10% from grains. The contribution of animal FP components were 19–66% from meat/poultry/seafood, 14–19% dairy, and 3–5% eggs.

Conclusions: The intake of foods considered to be good sources of plant protein was low. The overall diet quality of all adults was suboptimal regardless of plant protein intake. *Curr Dev Nutr* 2022;6:nzac035.

Keywords: plant protein, animal protein, plant and animal protein ratio, Healthy Eating Index (HEI), diet quality, What We Eat in America, NHANES, food categories

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Supplemental Tables 1–6 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/cdn/.

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Abbreviations used: AP, animal protein; DGA, Dietary Guidelines for Americans; FNDDS, Food and Nutrient Database for Dietary Studies; FP, Food Patterns; FPED, Food Patterns Equivalents Database; HEI, Healthy Eating Index; Q, quintile; WWEIA, What We Eat in America.

Introduction

Dietary patterns such as the Mediterranean diet, and vegetarian and semi-vegetarian diets are associated with a lower risk of chronic diseases, and have consistently included fruits and vegetables, whole grains, legumes, nuts, fish and seafood, lean meat, and poultry (1). These patterns are distinguished by their emphasis on most or all of these foods and are commonly described as plant based. Components of plant foods that have been associated with beneficial effects for health include fiber, certain vitamins and minerals, and numerous bioactive compounds (2). They are also low in food components associated with a higher risk of diseases – saturated fat from high-fat red and processed meats and high-fat dairy foods, added sugars, and sodium, as well as refined grains (1). In addition to the healthful constituents in plant foods, the beneficial effects of plant-based dietary patterns, may also be due to the replacement of high-fat and processed meats and high-fat dairy products with high-quality plant sources of protein and low-fat animal sources (3, 4). Greater emphasis was placed on including more plant-based protein foods in the 2010–2015 Dietary Guidelines for Americans (DGA) as knowledge of the benefits of plant-based diets evolved (5). Current dietary guidance communicates the DGA-2020–2025 recommendation for protein intake with the message to eat a variety of protein foods from animal and plant sources (6).

Legumes, nuts and seeds, and soy products have long been recommended as high-quality sources of plant protein since they provide a higher proportion of the essential amino acids than other plant foods; however, the overall intake of these foods is low. A previous analysis (7) of sources of protein intake by the US population showed that animal sources, including meat, eggs, and dairy foods, accounted for about two-thirds of protein intake, with the highest contributions from poultry, red meat, and mixed dishes containing poultry and red meat. The largest proportion of plant protein intake was from grains; beans and peas, nuts and seeds, and soy products accounted for <10% of plant protein intake. Similar patterns of animal and plant protein intake were observed among the Canadian (8) and French (9) populations. Between 1999 and 2016, trends in percentage of energy intake from different sources of protein among US adults showed small but significant increases in intakes of foods from all plant sources except refined grains, with the greatest increases from whole grains and nuts (10). This suggests the messages communicating dietary guidance recommendations, including increasing intake of plant protein, may be resonating among segments of the population.

Though animal and plant protein intakes of US adults have been described (7, 10), the contribution of each to total protein intake has not been evaluated by different levels of animal protein (AP) intake, which could inform dietary assessment, and communication and education strategies for improving dietary intake. The purpose of this study is to update previous estimates (7) of plant and animal protein intake of US adults in What We Eat in America (WWEIA), NHANES 2015–2018 among quintiles of AP protein intake. Foods and food components contributing to total protein intake of the 5 groups are reported and diet quality of each are compared.

Methods

Estimates are based on 1 d of dietary intake data from 9566 adults aged 20 y and older (4721 males and 4845 females) that provided a complete 24-h recall in WWEIA, NHANES 2015–2018. The NHANES sample was designed to be representative of the civilian, noninstitutionalized US population with oversampling of non-Hispanic blacks, non-Hispanic Asians, Hispanics, adults 80 y and older, and persons with low incomes to improve the accuracy of estimates of health status indicators for these population groups (11). All demographic information is self-reported by the participant, including race/ethnicity. The National Center for Health Statistics Research Ethics Review Board (USA CDC, 2015) approved the NHANES protocol. Participants provide informed consent upon entry in the study. Since this study was a secondary analysis of NHANES data, which are publicly available, Institutional Review Board approval was not needed or obtained for this analysis.

Dietary intake data collection and coding

Trained interviewers collected dietary intake data using the USDA Automated Multiple-Pass Method for the 24-h recall (12). This study used food intake data from the first of 2 nonconsecutive dietary recall days, which was collected in person. All foods reported in the dietary recall are coded using the USDA Food and Nutrient Database for Dietary Studies (FNDDS), which is a database of over 7000 foods, their nutrient values, and weights for typical food portions used to process data and estimate food and nutrient intakes from WWEIA, NHANES. Data reported in WWEIA, NHANES 2015–2016 and WWEIA, NHANES 2017–2018 were coded using FNDDS, 2015–2016 and FNDDS 2017–2018, respectively (13).

Determination of animal, plant, and USDA Food Patterns group proportions of FNDDS foods

The proportion of total protein intake that was from animal and plant sources was first determined. For each reported food and beverage in WWEIA, NHANES 2015–2016, and WWEIA, NHANES 2017–2018, proportions of protein from animal and plant sources were estimated from the ingredients in FNDDS 2015–2016 and FNDDS 2017–2018. Then, within animal and plant classifications, proportions from USDA Food Patterns (FP) (14) groups were calculated. The following procedure was used to determine the proportions from each reported food. Additional details related to these procedures can be found in **Supplemental Table 1**.

Single Ingredient Foods:

- Classify as Animal or Plant.
- Further classify into select USDA FP components (Meat, Poultry, Fish, Vegetables, Fruits, Grains, Dairy, Legumes, Soy products, Nuts/Seeds).

Mixed Ingredient Foods:
Foods with ingredients in FNDDS:

- Calculate the proportion of protein from animal sources and plant sources using the ingredients in FNDDS (sum of grams of protein from animal foods or from plant foods/total grams protein).
- Calculate the proportions of protein from select USDA FP components (sum of grams of protein in ingredients of a component/total grams protein).
- An ingredient that provided <5% of total protein in the mixed dish was not subclassified to USDA FP components unless it could be summed with other ingredients in the component. Otherwise, it was accounted for in "Miscellaneous."

Foods without ingredients in FNDDS:

- For foods without multiple variations or types (e.g. Kung Pao chicken), proportions from a similar food in FNDDS were used or a recipe was located online.
- For foods with multiple variations or types (e.g. pizza), standard proportions were used based on an existing code that did have ingredients. For example, total protein for 1 slice of pizza was estimated for each ingredient from food codes in FNDDS (e.g. dough ingredients from white pizza, vegetables and meat on pizza) and proportions were estimated for each variation of pizza using the protein amount for each ingredient.
- For burgers and sandwiches from restaurants, information from the company's website was used. If the information was not available, proportions from a similar commercial food item were used.

Calculations were done by 1 person (MKH). Decisions about estimating proportions for mixed ingredient foods without ingredients in FNDDS were made in consultation with a coauthor (AJM) and other nutrition staff. Data was crosschecked by filtering on FP components and sorting by amount of animal and plant protein to check classifications. Proportions of animal and plant protein, then all of the individual FP components were summed to check that all protein was accounted for. This approach was used instead of the Food Patterns Equivalents Database (FPED) because the ounce or cup equivalents for most foods do not directly translate to grams of protein intake. There is considerable variability in the protein content per 100 g within each food component.

Nutrient intake

Mean macronutrient intakes of each group were estimated using the nutrient values for each food in FNDDS 2015–2016 and FNDDS 2017–2018 (13) reported by the participant.

Contribution of USDA FP groups to total protein intakes

The USDA FP components (14) were used to describe the contribution of animal foods and plant foods to total protein intake. The WWEIA Food Categories (15) were used to describe the contribution of different types of foods to total protein intakes. Percentage contribution and percentage of adults within each quintile reporting foods from each category are reported.

Dietary quality

The Healthy Eating Index-2015 (HEI) was used as an indicator of dietary quality. The HEI-2015 was developed to evaluate conformity of the diet with the 2015 DGA (16). To determine the total HEI score, 13 component scores are summed, with a possible score ranging from 0 to 100 points; higher scores indicate closer adherence to 2015–2020 DGA recommendations. Scores for 9 of the components are based on their level of adequacy in the diet, where higher scores indicate greater intake up to a recommended amount. Scores are based on amount of intake of each component per 1000 kcal (17). These components and their maximum possible scores are total vegetables (5 points), greens and beans (5 points), total fruits (5 points), whole fruits (5 points), whole grains (10 points), dairy (10 points), total protein foods (5 points), seafood and plant proteins (5 points), and fatty acids, which is based on the ratio of MUFAs + PUFAs to SFAs (10 points). The remaining 4 components are scored based on their level of moderation in the diet, and higher scores reflect lower intake. These are refined grains (10 points), sodium (10 points), added sugars (10 points), and saturated fats (10 points). The HEI scoring algorithm (18) was used to calculate the total and component HEI-2015 score for each individual. Intake of the components was estimated utilizing the FPED 2015–2016 and 2017–2018 (14), and nutrient estimates were based on FNDDS 2015–2016 and 2017–2018.

Statistical analysis

The distribution of animal protein (AP) intake percentages was determined, and quintiles were used to differentiate groups. Quintile 1 (Q1) was the lowest AP and quintile 5 (Q5) was the highest. To determine the percent contribution of the FP components and the WWEIA food categories to total protein intake, the population proportion method was used (19), where the percent fraction of each component protein intake to the total protein intake of that component was calculated by the Ratio Procedure of the SUDAAN software. This procedure applies the survey stratification and primary sampling unit information and food-category-level specific poststratification weights to aggregate data at the food category level. The "PROC REGRESS" SAS callable SUDAAN procedure (SUDAAN release 11.0.3) (20, 21) pairwise t-tests were used to compare mean energy and nutrient intakes, HEI and component scores, and percent contribution of USDA FP groups to total protein intake, in a regression model adjusting for age (20–39, 40–59, 60+ y), sex (male/female), income (<130%, 130–350%, >350% Poverty Income Ratio), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic Asian, Other), smoking (current, former, never), weight status (<25, 25–30, >30 kg/m^2), and for the survey design effects resulting from NHANES' complex, multistage probability sampling (22, 23). All analyses used sample dietary weights to produce nationally representative estimates. Differences were considered significant at P <0.001.

Results

Demographic characteristics are shown in **Table 1**. There were small differences by race/ethnicity (P <0.001), but no other significant differences in demographic characteristics among the 5 groups.

Figures 1 and **2** illustrate the proportion of total protein from primary USDA FP groups which include estimates from components in mixed ingredient foods. Among the total population, approximately two-thirds of total protein intake was from animal sources, and one-third was from plant sources. The 5 groups differed significantly from each other for contribution to total protein intake by Nuts and Seeds (except Q3 and Q4), and by Grains (except Q2 and Q3). There were significant differences between the lowest 2 AP quintiles and the highest 2 AP quintiles for contribution to total protein intake from all components except vegetables (P <0.001). Among the lowest 2 quintiles, Dairy, Meat, and Poultry accounted for significantly more of total protein intake by Q2 compared with Q1 (P <0.001) whereas Legumes, Nuts and Seeds, Soy and Grains accounted for less (P <0.001). The same was true when Q5 was compared with Q4. Q3 did not differ significantly from Q2 for the proportions of total protein from each plant component except Nuts and Seeds. Among the animal protein FP components, Q3 did not differ from Q4 for Dairy, Fish, and Eggs. The WWEIA Food Categories that contributed to total protein intake of each group are shown in **Supplemental Tables 2–6** and are consistent with the proportions from each USDA FP group. Among Q1, Pasta and pasta mixed dishes, Nuts and Seeds, and Yeast breads were top foods contributing to total protein intake. Among Q5, single animal foods – Chicken, Beef, Fish, and Eggs were top contributors. Intake of the middle quintiles (Q2 to Q4) from various categories was intermediate between Q1 and Q5 and top contributors included both meat items and grain-based mixed dishes.

Table 2 shows energy and macronutrient intake by quintile. Mean energy intakes of Q1 and Q5 were significantly lower than Q2 (P <0.001). Total protein intakes and percent animal and plant protein were significantly different between all quintiles (P <0.001). Q1 and Q2 had significantly higher carbohydrate intakes compared with Q3, Q4, and Q5 (P <0.001). Fat and saturated fat intake of Q1 was significantly lower than Q2 through Q5 (P <0.001).

Total and HEI component scores are shown in **Table 3**. The total HEI score of Q1 (53.5) was significantly higher compared with all other quintiles, which did not differ significantly from each other. Their scores were Q2: 50.1; Q3: 48.7; Q4: 49.1; and Q5: 48.0. HEI-component scores of the 5 groups differed significantly from each other for Protein Foods, where Q5 had the highest score, and Q1 had the lowest (P <0.001). Q1 had a significantly higher score than the other groups for Total Fruit, Seafood/Plant Proteins, Whole Grains, Fatty Acids, Saturated fat, and Sodium components, whereas Q4 and Q5 had significantly better scores

TABLE 1 Demographic characteristics of adults (N = 9564) by quintile of animal protein (AP) intake, What We Eat in America, NHANES 2015–2018

Demographic characteristic	ALL % (SE)	Q1[1] % (SE)	Q2[2] % (SE)	Q3[3] % (SE)	Q4[4] % (SE)	Q5[5] % (SE)	*P*[6]
Gender							
Male	49 (0.8)	43 (1.7)	48 (1.8)	51 (1.9)	51 (1.8)	52 (1.7)	0.002
Female[7]	51 (0.8)	57 (1.7)	52 (1.8)	49 (1.9)	49 (1.8)	48 (1.7)	
Age							
20–39	35 (0.8)	34 (1.7)	32 (1.6)	35 (1.7)	35 (1.7)	39 (1.6)	0.004
40–59	36 (0.8)	34 (1.7)	37 (1.8)	36 (1.9)	35 (1.8)	37 (1.8)	
60+	29 (0.7)	32 (1.5)	31 (1.6)	29 (1.6)	30 (1.7)	24 (1.4)	
Race/ethnicity							
Non-Hispanic white	64 (0.7)	61 (1.5)	63 (1.5)	66 (1.5)	67 (1.5)	61 (1.5)	<.0001
Non-Hispanic black	11 (0.3)	10 (0.6)	11 (0.7)	11 (0.7)	11 (0.7)	14 (0.8)	
Hispanic	15 (0.4)	16 (0.9)	16 (1.0)	15 (1.0)	15 (0.9)	15 (0.9)	
Non-Hispanic Asian	6 (0.2)	10 (0.6)	6 (0.5)	5 (0.5)	4 (0.4)	5 (0.4)	
Other[8]	4 (0.3)	5 (0.8)	4 (0.8)	4 (0.6)	4 (0.6)	5 (0.7)	
Income level							
≤130% PIR[9]	18 (0.5)	19 (1.3)	17 (1.1)	15 (1.1)	18 (1.2)	22 (1.2)	0.01
>130 to ≤350% PIR	27 (0.7)	25 (1.4)	29 (1.6)	26 (1.5)	27 (1.5)	27 (1.4)	
>350% PIR	46 (0.8)	46 (1.8)	44 (1.8	48 (1.9)	46 (1.9)	45 (1.8)	
Weight status[10]							
Normal	27 (0.7)	31 (1.6)	28 (1.6)	25 (1.7)	26 (1.7)	24 (1.4)	0.01
Overweight	32 (0.8)	33 (1.7)	32 (1.7)	33 (1.8)	30 (1.7)	31 (1.6)	
Obese	41 (0.8	36 (1.6)	41 (1.8)	42 (1.9)	45 (1.8)	44 (1.7)	
Physical Activity[11]							
Low	34 (0.8)	34 (1.6)	33 (1.6)	32 (1.7)	33 (1.7)	34 (1.6)	0.14
Moderate	8 (0.4)	9 (0.9)	10 (1.0)	14 (1.4)	13 (1.3)	10 (1.1)	
High	57 (0.8	57 (1.7)	57 (1.8)	55 (1.9)	54 (1.9)	56 (1.7)	
Smoking							
Never	55 (1.4)	60 (1.7)	56 (1.9)	59 (1.8)	56 (1.9)	54 (1.7)	0.07
Former	25 (0.3)	27 (1.6)	25 (1.5)	25 (1.7)	25 (1.7)	26 (1.6)	
Current	20 (1.1)	15 (1.1)	19 (1.4)	16 (1.2)	19 (1.4)	20 (1.4)	
Dietary supplement use							
Yes	58 (0.8)	60 (1.7)	59 (1.7)	59 (1.8)	57 (1.8)	53 (1.7)	0.05
No	43 (0.8)	40 (1.7)	41 (1.7	41 (1.8)	43 (1.8)	47 (1.7)	

[1]Q1: Lowest quintile of animal protein (AP) (<49.8%).
[2]Q2: Second lowest quintile of AP (49.8–61.7%).
[3]Q3: Middle quintile of AP (61.8–70.0%).
[4]Q4: Second highest quintile of AP (70.1–78.4%).
[5]Q5: Highest quintile of AP (≥78.4%).
[6]Differences in percentages between the 5 groups for each demographic were made using Wald Chi Square tests and were considered significant at $P < 0.001$.
[7]Excludes pregnant and lactating females.
[8]Includes Native American, Alaskan Native, Pacific Islander, multiracial.
[9]PIR: Poverty Income Ratio; family income expressed as percent of the federal poverty level.
[10]Normal weight: BMI<25 kg/m^2; overweight: BMI: 25–30 kg/m^2; obese: ≥30 kg/m^2.
[11]Includes all physical activity, regardless of purpose (recreation, in the performance of work, or as a means of transportation), with each vigorous-intensity minute counted as the equivalent of 2 moderate-intensity minutes. Activity levels (minutes per week): inactive/low: <150; moderate: 150–299; active: ≥300.

for Refined Grains and Dairy compared with Q1, Q2, and Q3, and Q3 for Dairy only ($P < 0.001$). There were no differences between the 5 groups for scores on any of the Fruit and Vegetable components or for Added Sugars except for significantly higher scores for the Fruit components among Q1.

Discussion

Results of this study indicate that among US adults, lower intakes of protein from animal sources and higher intakes from plant sources are primarily due to a higher intake of grains and grain products, and to a smaller degree from nuts and seeds and legumes. Though the total HEI score of Q1 was significantly better than the other 4 groups, a high intake of refined grains and low intake of protein foods, including high-quality sources of plant-based proteins, contributed to their lower diet quality. The overall diet quality of all 5 groups was fair at best, highlighting the need to promote the intake of healthy forms of all foods.

A higher proportion of total protein intake from plant sources was associated with significantly lower total protein intakes, which was related to a higher intake of grains and grain products. In contrast to these results, there were no differences in total protein intake by quartile of plant protein intake among French adults, where the proportion of plant protein among the quartiles ranged from 26.6% to 41.9% compared with 15% to 56% among quintiles in this study (9). The differences may reflect cultural differences in food intake. A simulation using dietary

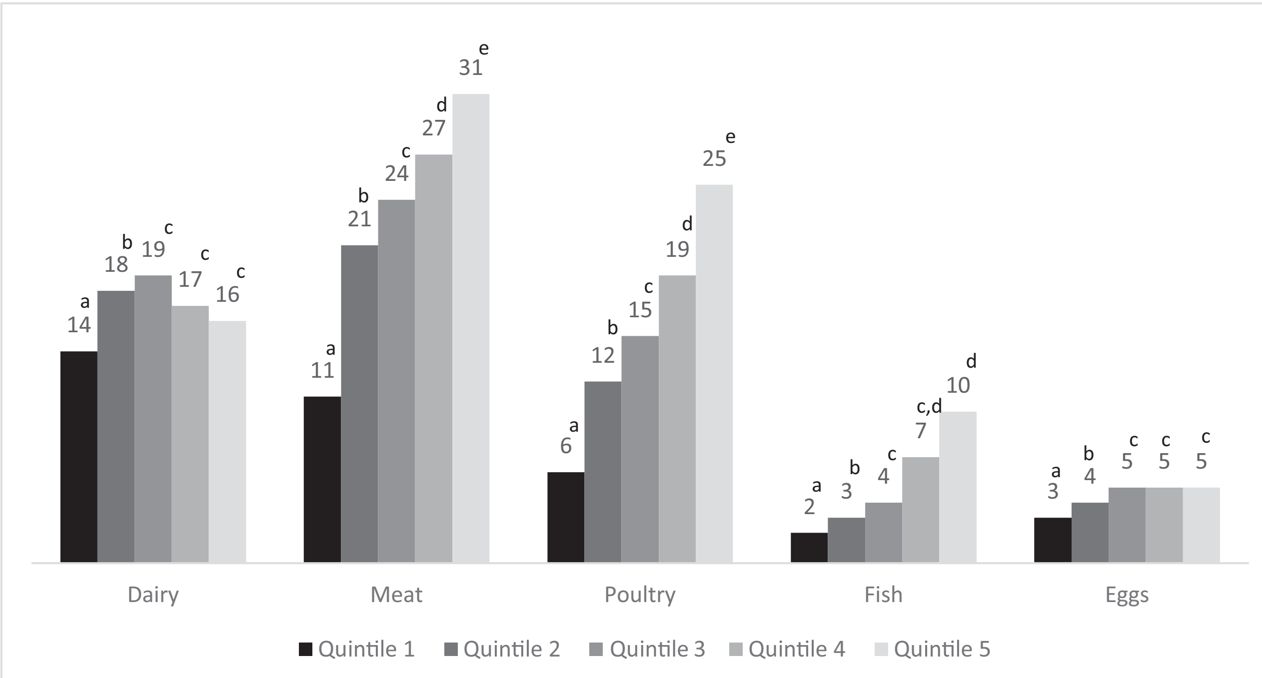

FIGURE 1 Percentage contribution of animal food components[1] to total protein intake of adults (N = 9564) by quintile of animal protein (AP) intake[2].
[a,b,c,d,e]Results with different superscripts are significantly different, P <0.001.
[1]Does not include protein from Miscellaneous foods including baked goods and alcoholic beverages so percentages from animal and plant sources may not add to 100%.
[2]Group comparisons were made by t-tests in a regression model adjusting for age, sex, income, race/ethnicity, smoking, and weight status.

intake in the Canadian Community Health Study doubled reported intake amounts of plant-based proteins and reduced meat intake by 50%. There was a small, but significant decrease in protein of 4 g (24). In addition, in a randomized controlled trial, participants consumed a diet that was an animal: plant protein mix of either 70:30, 50:50, or 30:70%. Total protein intake decreased, respectively, but provided 15% of energy in the 30:70 group (4). However, although protein intake may be lower when protein from plants replace that from animal sources, a previous analysis of protein intake of the US population showed overall prevalence of inadequate protein intake was low but was highest among adolescent females 14–18 y and older males aged over 70 y (25). Though replacing animal foods with high-quality plant protein foods is unlikely to result in inadequate intake in the population, it is important to be aware of who may be at risk of low protein intake including athletes (26) and elderly individuals (27).

HEI-component scores were consistent with the differences in sources of protein between the quintiles, as observed in other studies (9, 28, 29, 30). Q1 had a better score for the Seafood/Plant protein component, which was related to a higher intake of plant-based protein foods. Nuts and seeds, legumes, and soy products together accounted for ∼14% of total protein intake by Q1 compared with seafood, which contributed 2% to total protein intake. The score for the Saturated Fat and Fatty Acids components were significantly better among Q1 compared with all other quintiles and was inversely related to animal protein intake. However, percent of energy from saturated fat among Q1 was 12%, over the recommendation of 10% (6). Furthermore, because seafood intake was lower among Q1, their better score for the Fatty Acids component compared with all other quintiles was probably due in part to the higher intake of nuts and seeds. Scores of Q1, Q2, and Q3 for the Whole grains and Refined grains components reflected the high contribution to protein intake from grain products and grain-based dishes though their scores suggested refined grains were more frequently consumed. The Fruit and Vegetable components and the Added Sugars component did not differ between the quintiles. Although Q1 had a significantly lower score for the Dairy component compared with the other quintiles, the differences between the 5 groups in percent contribution of dairy to protein intake were not large. Though the total HEI score of Q1 was significantly higher than all other groups, diet quality of all quintiles was fair at best. Though some improvements may be occurring within the population (10), current diet quality is suboptimal, so replacing animal protein with plant-based protein sources within the context of prudent food choices including legumes, fruits and vegetables, whole grains, and dairy foods is needed to improve overall diet quality.

A flexitarian diet that includes small amounts of meat has been suggested as a practical approach for increasing plant-based protein intake (4). In the randomized trial comparing intake with different levels of plant protein intake, consuming plant-based protein sources at either 50 or 70% resulted in significantly higher fiber and PUFA intakes and lower saturated fat and cholesterol intakes compared with both

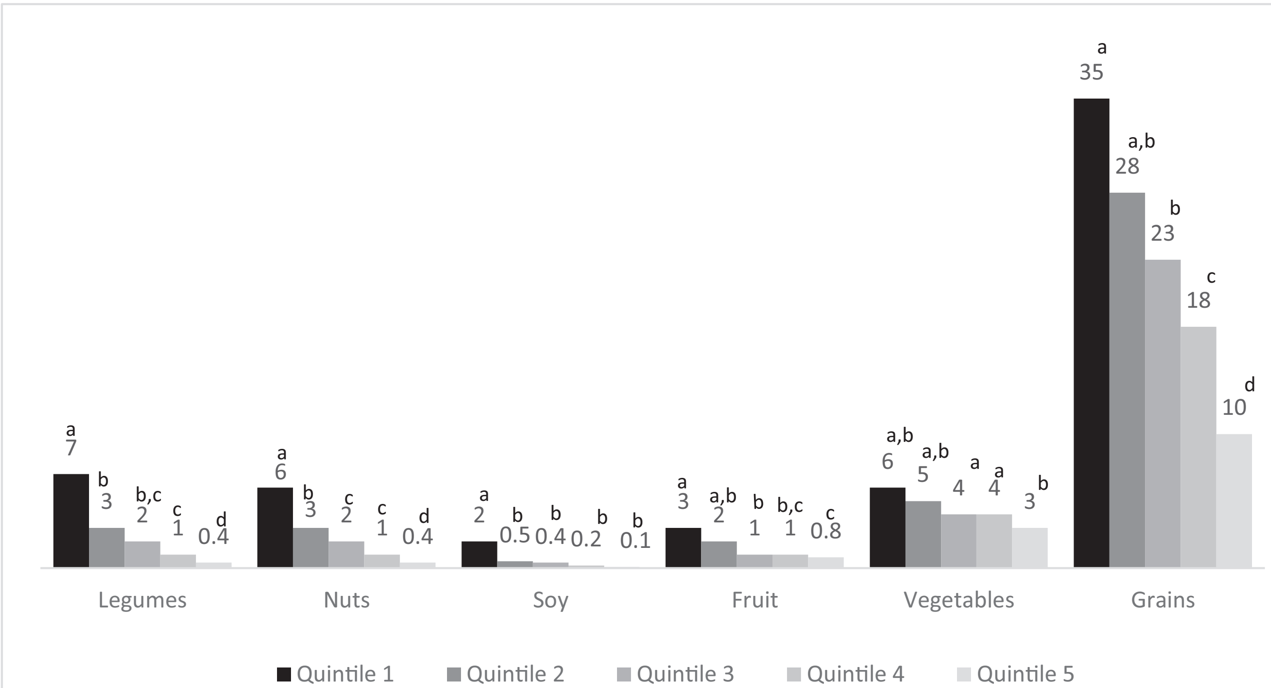

FIGURE 2 Percentage contribution of plant food components[1] to total protein intake of adults (N = 9564) by quintile of animal protein (AP) intake[2].
[a,b,c,d,e]Results with different superscripts are significantly different, P <0.001.
[1]Does not include protein from Miscellaneous foods including baked goods and alcoholic beverages so percentages from animal and plant sources may not add to 100%.
[2]Group comparisons were made by t-tests in a regression model adjusting for age, sex, income, race/ethnicity, smoking, and weight status.

baseline and the 30% plant protein diet. Differences were also significantly greater among the 70% diet compared with the 50% diet. In addition, total cholesterol and LDL but not HDL and triglycerides improved significantly in the 2 high plant groups (4). Modeling studies have illustrated that protein from plant sources can replace animal sources without risking inadequate intakes of protein or most other micronutrients.

TABLE 2 Energy and macronutrient intake of adults (N = 9564) by quintile of animal protein (AP) intake[1], What We Eat in America, NHANES 2015–2018

Nutrient	ALL Mean (SE)	Q1[2] Mean (SE)	Q2[3] Mean (SE)	Q3[4] Mean (SE)	Q4[5] Mean (SE)	Q5[6] Mean (SE)
Energy, kcal	2129 (20)	2030 (32)[a]	2202 (29)[b]	2172 (28)[b,c]	2197 (33)[b,c]	2036 (31)[a,c]
Protein, g[7]	82.2 (1.1)	61 (1.2)[a]	75 (1.0)[b]	81 (1.2)[c]	90 (1.2)[d]	104 (1.8)[e]
Animal protein, g	54.8 (0.2)	23 (1.4)[a]	43 (0.8)[b]	55 (0.8)[c]	68 (1.0)[d]	91 (2.1)[e]
Animal protein, %	66.7 (0.3)	37 (0.5[a]	57 (0.1)[b]	66 (0.1)[c]	74 (0.9)[d]	85 (0.2)[e]
Plant protein, g	25.8 (0.3)	35 (0.9)[a]	31 (0.6)[b]	27 (0.4)[c]	23 (0.3)[d]	16 (0.3)[e]
Plant protein, %	31.4 (0.3)	56 (0.7)[a]	40 (0.2)[b]	33 (0.1)[c]	25 (0.1)[d]	15 (0.2)[e]
Carbohydrate, g	244 (2.7)	263 (2.6)[a,b]	270 (4.3)[b]	255 (3.8)[a,b]	243 (4.3)[a,c]	197 (3.9)[d]
Fat, g	86.1 (0.9)	77 (1.6)[a]	86 (1.5)[b]	88 (1.4)[b]	91 (1.7)[b]	87 (1.3)[b]
Saturated fat, g	28.0 (0.4)	23 (0.5)[a]	28 (0.5)[b]	29 (0.5)[b,c]	30 (0.6)[c]	29 (0.6)[b,c]
Polyunsaturated fat, g	20.1 (0.3)	20 (0.5)	20 (0.5)	21 (0.5)	21 (0.5)	19 (0.4)

[1]Group comparisons were made by t-tests in a regression model adjusting for age, sex, income, race/ethnicity, smoking, and weight status.
[2]Q1: Lowest quintile of animal protein (AP) (<49.8%).
[3]Q2: Second lowest quintile of AP (49.8–61.7%).
[4]Q3: Middle quintile of AP (61.8–70.0%).
[5]Q4: Second highest quintile of AP (70.1–78.3%).
[6]Q5: Highest quintile of AP (≥78.4%).
[7]Percentages and grams of animal and plant protein may not total 100% or total protein grams due to allocation of some ingredients to "Miscellaneous" protein.
[a,b,c,d,e]Results with different superscripts are significantly different, *P* <0.001.

TABLE 3 Healthy Eating Index (HEI) total and component scores of adults (N = 9564) by quintile of animal protein (AP) intake[1], What We Eat in America, NHANES 2015–2018

HEI components (possible score)	Q1[2] Mean (SE)	Q2[3] Mean (SE)	Q3[4] Mean (SE)	Q4[5] Mean (SE)	Q5[6] Mean (SE)
Total HEI score (100)	53.8 (0.6)[a]	50.0 (0.5)[b]	48.8 (0.5)[b]	49.1 (0.4)[b]	48.6 (0.4)[b]
Adequacy components					
Total vegetables (5)	3.0 (0.07)	2.9 (0.06)	3.0 (0.06)	3.1 (0.05	2.9 (0.06)
Greens and beans (5)	1.6 (0.08)	1.4 (0.07)	1.4 (0.08)	1.5 (0.08)	1.3 (0.07)
Total fruits (5)	2.3 (0.08)[a]	2.0 (0.07)[a]	1.9 (0.07)[b]	1.9 (0.07)[b]	1.7 (0.07)[b]
Whole fruits (5)	2.3 (0.08)[a]	2.1 (0.08)[a,b]	2.1 (0.08)[a,b]	2.0 (0.08)[a,b]	1.8 (0.08)[b]
Whole grains (10)	3.6 (0.14)[a]	2.7 (0.12)[b]	2.6 (0.12)[b,c]	2.1 (0.11)[c]	1.6 (0.09)[d]
Dairy (10)	3.6 (0.11)[a]	4.8 (0.11)[b]	5.1 (0.12)[b]	5.2 (0.12)[b]	5.3 (0.13)[b]
Total protein foods (5)	3.4 (0.06)[a]	4.0 (0.05)[b]	4.3 (0.04)[c]	4.7 (0.03)[d]	4.8 (0.03)[e]
Seafood/plant proteins (5)	3.1 (0.08)[a]	2.4 (0.08)[b]	2.0 (0.08)[c]	1.8 (0.07)[c,d]	1.6 (0.08)[d]
Fatty acids (10)	6.1 (0.14)[a]	5.1 (0.13)[b]	4.6 (0.14)[b]	4.5 (0.13)[b,c]	4.5 (0.12)[c]
Moderation components					
Sodium (10)	5.6 (0.13)[a]	4.7 (0.12)[b]	4.2 (0.13)[b,c]	3.8 (0.12)[c,d]	3.2 (0.11)[d]
Refined grains (10)	5.4 (0.14)[a]	5.3 (0.13)[a]	5.6 (0.13)[a]	6.8 (0.11)[b]	8.3 (0.08)[c]
Added sugars (10)	7.0 (0.12)	6.8 (0.12)	6.8 (0.12)	7.0 (0.12)	7.1 (0.11)
Saturated fat (10)	6.8 (0.11)[a]	5.9 (0.12)[b]	5.1 (0.12)[c]	4.8 (0.13)[c]	4.6 (0.12)[c]

[1]Group comparisons were made by t-tests in a regression model adjusting for age, sex, income, race/ethnicity, and smoking.
[2]Q1: Lowest quintile of animal protein (AP) (<49.8%).
[3]Q2: Second lowest quintile of AP (49.8–61.7%).
[4]Q3: Middle quintile of AP (61.8–70.0%).
[5]Q4: Second highest quintile of AP (70.1–78.3%).
[6]Q5: Highest quintile of AP (≥78.4%).
[a,b,c,d,e]Results with different superscripts are significantly different, *P* <0.001.

In a model using the dietary intakes of French adults, ≥50% and ≤100% of animal protein was replaced with diverse plant food sources. Nutrient adequacy was maintained or improved, particularly at the 50% replacement level. The diverse mix included legumes, nuts and seeds, and whole grains, but not refined grains (9). Dietary patterns developed for the 2020 Dietary Guidelines Scientific Advisory Committee included the US Healthy Eating Pattern, as well as the Healthy Vegetarian Pattern and the Healthy Mediterranean Pattern. Most nutrients could be obtained with these patterns by the general population 2 y and older at or above recommended amounts with the exception of vitamins D and E, folate, and iron (1). Regardless of what dietary pattern is consumed, a diversity of healthful choices selected from within different food groups appears to be key to achieving adequate nutrient intake and the best possible diet quality.

A primary strength of this study is the NHANES sample, which is nationally representative of the US population. Dietary intake is collected using the Automated Multiple Pass Method for 24-h recall which has been shown to provide accurate estimates of intake (31). The process for estimating animal and plant protein intake as well as intake of the USDA FP groups included estimates for all mixed ingredient items with the exception of some baked goods (e.g. cakes and cookies) and alcoholic beverages. With the exception of small amounts of eggs and dairy that might be present in baked goods, most protein from these foods would come from plant sources and were classified as such. They were classified as "Miscellaneous," not into FP components, and accounted for only 2% of total protein; however, there are several limitations to consider when interpreting results. Dietary estimates are based on a single 24-h intake per sample person, which provides an estimate of daily mean intake of the US population on any given day of the year; however, it does not represent long-term consumption. One day of dietary intake has been shown to be adequate for estimating and comparing mean intakes of population groups (32). In addition, nationally representative estimates are produced because of the NHANES sample design, and the application of dietary sample weights, which adjust for day of the week, probability of selection, and nonresponse (11). Lastly, although the process for developing the database was methodical, the percentages from animal and plant protein for the foods are only estimates of proportions consumed by the population.

In conclusion, the primary source of plant protein was grains in grain products and grain-based mixed dishes, primarily in the form of refined grains. Better diet quality scores among those with a lower percentage of protein from animal sources suggest plant protein replaced animal protein in the diet to some degree. However, intake of protein from plant foods considered to be high-quality protein sources was low. Further, the overall diet quality of all adults was suboptimal, regardless of intake of plant-based protein foods. Encouraging plant-based protein sources as replacement for animal protein sources, particularly high-fat meats and dairy, needs to be in the context of promoting healthy food choices in general.

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Data Availability

Data described in the manuscript are publicly and freely available without restriction at https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/wweia-documentation-and-data-sets/.

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