

# Commonly consumed protein foods contribute to nutrient intake, diet quality, and nutrient adequacy<sup>1–7</sup>

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## ABSTRACT

The amount of dietary protein needed to prevent deficiency in most individuals is defined in the United States and Canada by the Recommended Dietary Allowance and is currently set at 0.8 g protein · kg<sup>-1</sup> · d<sup>-1</sup> for adults. To meet this protein recommendation, the intake of a variety of protein food sources is advised. The goal of this article is to show that commonly consumed food sources of protein are more than just protein but also significant sources of essential nutrients. Commonly consumed sources of dietary protein frequently contribute substantially to intakes of nutrients such as calcium, vitamin D, potassium, dietary fiber, iron, and folate, which have been identified as nutrients of “concern” (i.e., intakes are often lower than recommended). Despite this, dietary recommendations to reduce intakes of saturated fat and solid fats may result in dietary guidance to reduce intakes of commonly consumed food sources of protein, in particular animal-based protein. We propose that following such dietary guidance would make it difficult to meet recommended intakes for a number of nutrients, at least without marked changes in dietary consumption patterns. These apparently conflicting pieces of dietary guidance are hard to reconcile; however, we view it as prudent to advise the intake of high-quality dietary protein to ensure adequate intakes of a number of nutrients, particularly nutrients of concern. *Am J Clin Nutr* 2015;101(Suppl):1346S–52S.

**Keywords:** diet quality, mineral, nutrient density, vitamin, nutrient rich, animal protein

## INTRODUCTION

Accumulating research has focused on the association between the amount, quality and type, and timing of protein intake and health outcomes (1, 2). Emerging scientific evidence indicates that intakes of dietary protein moderately greater than the Recommended Dietary Allowance (RDA)<sup>8</sup> of 0.8 g protein · kg<sup>-1</sup> · d<sup>-1</sup> for adults (3) may be beneficial for some people such as older adults (4) and physically active individuals (5). In addition, moderately higher intakes of dietary protein greater than the current RDA may help reduce the risk of chronic diseases such as obesity, cardiovascular disease, type 2 diabetes, osteoporosis, and sarcopenia (1, 6).

An important consideration in dietary planning is how food sources of protein and different dietary patterns meeting protein needs affect nutrient intake, nutrient adequacy, and diet quality. Diet quality is commonly defined as the ability to achieve recommended nutrient intakes within recommended energy (calorie) intake amounts (7, 8). There are several reasons why this topic deserves consideration. One is that the risk or prevention of

chronic diseases cannot be predicted simply by the intake of a single nutrient, such as protein in a food or food group, but rather by the overall nutrient intake of the diet consumed within energy needs (7, 8). Another reason is that many North Americans' diets are far from optimal, as evidenced by the high prevalence of overweight and obesity and nutrient shortfalls, as well as findings that their dietary consumption patterns may increase the risk of inadequate intakes of a number of nutrients (9–12).

The overarching themes of the 2010 *Dietary Guidelines for Americans* (DGA) are “to maintain calorie balance over time to achieve and sustain a healthy weight” and “to focus on consuming nutrient-dense foods and beverages” (11). The 2010 DGA states that potassium, dietary fiber, calcium, and vitamin D

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<sup>8</sup> Abbreviations used: DGA, *Dietary Guidelines for Americans*; DIAAS, Digestible Indispensable Amino Acid Score; DRI, Dietary Reference Intake; HEI, Healthy Eating Index; PANDiet, Probability of Adequate Nutrient Intake Diet; PDCAAS, Protein Digestibility Corrected Amino Acid Score; RDA, Recommended Dietary Allowance.

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are nutrients of public health concern because they are often underconsumed and their underconsumption is associated with risk of various adverse health consequences (11). Other nutrients of concern for specific population groups include iron and folate for pregnant women and vitamin B-12 for older adults (individuals aged  $\geq 50$  y) (11). In addition, the 2010 DGA calls for reductions in intakes of saturated fat, solid fats, added sugars, and refined grains (11). A challenge created by these recommendations, and addressed in this article, is the call for simultaneous reductions in saturated and solid fats and increased intakes of nutrients of concern. We view these pieces of dietary advice as incongruous because a number of commonly consumed sources of dietary protein, although contributing significantly to intakes of nutrients of concern, are also significant contributors to intakes of saturated fat and solid fats. We propose that continued guidance to reduce intakes of saturated fat and solid fats may, if adopted without marked changes in dietary patterns, result in further shortfalls in intakes of nutrients of concern.

In addition to findings that many North Americans are exceeding the 2010 DGA goals for energy but falling short of intake goals for other essential nutrients, there is evidence that some population groups fail to consume recommended protein intakes (13), let alone higher protein intakes that are postulated to be beneficial for health (4, 14). Considering that excess energy intake can contribute to overweight/obesity, it is important to meet dietary protein recommendations (3), and potentially higher protein intakes for some population groups and individuals, within energy needs (14). There are postulated to be a number of advantages to higher than recommended intakes of dietary protein to promote satiety and leverage other nutrients, which are discussed in greater detail by Leidy et al. (15) in this supplement issue.

The aim of this article is to examine how commonly consumed food sources of protein, particularly nutrient-dense protein sources, contribute to nutrient intake (emphasizing nutrients that are underconsumed), nutrient adequacy, and diet quality. Our *a priori* hypothesis was that dietary patterns that emphasize consumption of nutrient-dense proteins (7, 8) to meet protein recommendations would have a positive influence on diet quality and contribute to nutrient adequacy without exceeding energy needs. In addition, continuing advice to reduce saturated fat intake would, we propose, result in “pressure” to reduce the intake of many commonly consumed nutrient-dense protein sources, which may lower diet quality (7, 8). We acknowledge that there are *bona fide* research gaps that need to be filled in the area of protein and nutrient intake and these are highlighted.

## CURRENT PROTEIN RECOMMENDATIONS, FOOD SOURCES, AND INTAKE

The Dietary Reference Intakes (DRIs) specify an RDA of  $0.80 \text{ g}$  of good quality protein  $\cdot \text{kg body weight}^{-1} \cdot \text{d}^{-1}$  for adults aged  $\geq 19$  y (3). Although good-quality protein intake is recommended by the DRIs, this term is not defined (3). The WHO defines protein quality by the amount and proportion of individual amino acids that can be absorbed from and used by the body (16); however, the best method to measure protein quality recently was updated to yield a new scoring system named the Digestible Indispensable Amino Acid Score (DIAAS), which describes protein quality on the basis of ileal digestibility and which has been recommended as a replacement for the Protein

Digestibility Corrected Amino Acid Score (PDCAAS) scoring system (17). The use of the DIASS system (which has ramifications for how individual amino acids are treated from an adequacy perspective) results in foods being scored, insofar as protein quality is concerned, with scores similar to PDCAAS but allows for quality rankings on the basis of ileal digestibility and is not artificially truncated at 1.0 (17). Regardless of which score is used, however, protein sources such as meat, poultry, fish, eggs, isolated soy protein, and dairy foods (milk, cheese, and yogurt) provide all 9 indispensable (essential) amino acids and are considered to be sources of high-quality protein (3, 17). Because proteins found in plants, legumes, grains, nuts, seeds, and vegetables can be deficient in one or more of the indispensable amino acids, these foods are considered lower-quality sources of protein (17).

Food sources of protein and/or the proportion of total protein intake from animal compared with plant sources have been examined in several studies (18–20). Researchers recently examined food sources of protein intake by using dietary intake data from nationally representative samples of individuals  $\geq 2$  y of age ( $n = 17,386$ ) who participated in the NHANES 2007–2010 (VL Fulgoni, unpublished observations, 2014). The top food sources of protein in descending order, with little difference observed between males and females (data not shown), are shown in **Table 1**. Although reducing energy intake is a major focus of the 2010 DGA, note that poultry and meats, the top 2 dietary sources of protein, were the 6th and 12th ranked sources, respectively, of dietary energy intake in the same survey (VL Fulgoni, unpublished observations, 2009). Both poultry and meats contributed  $<4\%$  to total daily energy intake. In contrast, breads, rolls, and tortillas were the fourth largest contributors to protein intake but the leading source of dietary energy, contributing 7% to total energy intake. The most commonly consumed protein sources (Table 1) are similar to those found in an earlier investigation that used data from NHANES 2003–2006 (18). Both studies indicated that animal food proteins are major contributors to dietary protein intake and yet are relatively low contributors to total dietary energy intake.

A study in older adults with the use of data from NHANES 2005–2006 found that, on average,  $>60\%$  of protein intake

**TABLE 1**

Top food sources of daily dietary protein from NHANES 2007–2010<sup>1</sup>

Food	Rank	Intake	
		Total protein	Intake <sup>2</sup>
		%	g
Poultry	1	10.0	$7.9 \pm 0.3$
Meats	2	9.5	$7.5 \pm 0.2$
Mixed dishes—meat, poultry, fish	3	7.5	$5.9 \pm 0.2$
Breads, rolls, tortillas	4	6.4	$5.1 \pm 0.1$
Milk	5	6.4	$5.1 \pm 0.1$
Cured meats/poultry	6	6.0	$4.7 \pm 0.1$
Mixed dishes—pizza	7	4.8	$3.8 \pm 0.2$
Cheese	8	4.8	$3.8 \pm 0.1$
Mixed dishes—grain-based	9	4.4	$3.5 \pm 0.2$
Mixed dishes—sandwiches	10	4.1	$3.2 \pm 0.2$
Eggs	11	3.2	$2.5 \pm 0.1$
Plant-based protein foods	12	3.2	$2.5 \pm 0.1$
Seafood	13	3.1	$2.4 \pm 0.2$

<sup>1</sup> $n = 17,386$ . The listed foods comprise  $\sim 73\%$  of total daily protein intake (VL Fulgoni, unpublished observations, 2014).

<sup>2</sup>Values are means  $\pm$  SEMs.

came from animal sources, with ~61% for the oldest (>71 y) age group and ~65% for adults aged 51–70 y (19). The main animal protein sources in descending order were as follows: dairy, beef, poultry, pork, fish, and eggs (19). The likelihood of meeting the RDA for protein increased as the percentage of intake of protein from animal sources increased and the percentage of protein from total plant sources decreased. These data are similar to other data (20) in which the top dietary protein sources were, in descending order: poultry, dairy, refined grains, and beef. Animal- and plant-source protein foods comprised ~66% and 34%, respectively, of total daily protein intake; however, sex, race, age, and body weight status all influenced the contribution of protein sources within different food groups (20). The researchers suggested that demographic factors and weight status should be considered when designing intervention programs to modify protein intakes (20).

Current protein intake in Americans ranges from 14% to 16% of energy intake, according to the most recent analysis of data from NHANES 2009–2010 in individuals aged  $\geq 2$  y (VL Fulgoni, unpublished observations, 2014). This is identical to the protein range of energy intake reported in an earlier study that used data from NHANES 2003–2004 (13). The earlier data (13) showed that, although in general Americans met the recommendations for dietary protein, a higher proportion of adolescent and older women compared with men in similar age groups did not consume an adequate amount of protein (13). Although there is insufficient evidence to suggest a Tolerable Upper Intake Level for protein (i.e., a level above which the potential risk of adverse effects may increase), the risk of adverse effects from food sources appears to be very low, and there is consensus that protein intakes up to 35% of energy (defined in the Acceptable Macronutrient Distribution Range as the upper limit for dietary protein intake) for adults are without health risk (3). The acknowledgment that the Acceptable Macronutrient Distribution Range defines an upper limit for protein intake at 35% of total energy intake highlights that there is a wide range of protein intakes that are considered to be healthy (3). For example, for a 70-kg man consuming 10.5 MJ/d (~2500 kcal), the protein RDA would equate to an intake of 56 g protein/d or ~9% of total dietary energy, whereas 35% of daily total energy intake (~219 g protein) would equate to an intake of protein of  $\sim 3.1 \text{ g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}$ .

## NUTRIENT DENSITY AND NUTRIENT PROFILING OF FOODS AND DIETS

Current recommendations to meet nutrient needs, including protein, focus on selecting from a wide variety of foods (7, 8, 10, 11, 21, 22). A fundamental premise of the 2010 DGA is that nutrients come from foods, particularly from nutrient-dense foods (11). Nutrient density is a long-standing dietary principle and a cornerstone of the 2010 DGA and the USDA's MyPlate (11, 23). However, it is recognized that there is no strict definition of "nutrient density" or a "nutrient-dense" food, and issues related to developing these definitions have been identified (21, 24). Nonetheless, there is a general consensus that "nutrient-dense foods provide vitamins, minerals, and other substances that may have positive health effects, with relatively few calories. They are lean or low in solid fats, and minimize or exclude added solid fats, added sugars, and added refined starches, as these add calories but few essential nutrients or dietary fiber" (11). Although this definition has been criticized as being ambiguous (21), we use it here

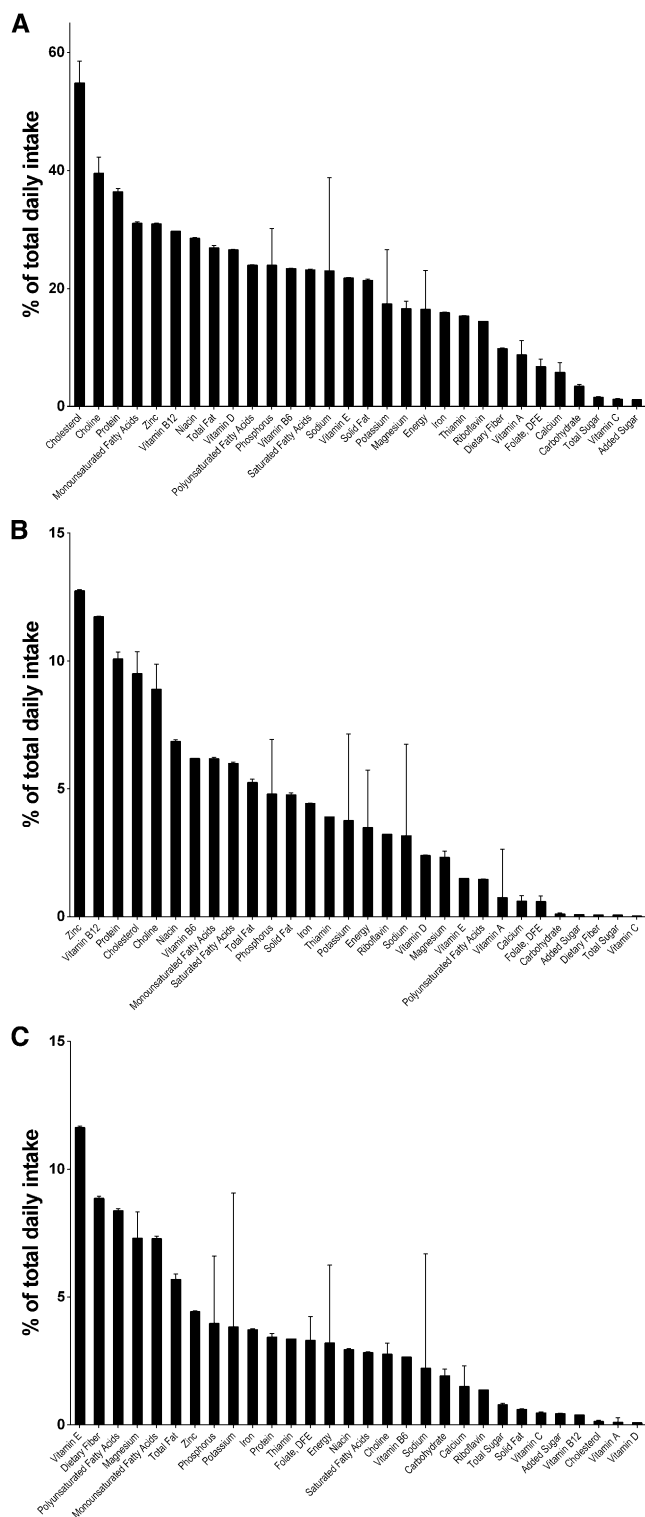
as the most common description of nutrient density and nutrient-dense foods. In contrast to nutrient-dense food choices are foods with low nutrient but relatively high energy (particularly from added sugars) content or what are commonly referred to as energy-dense and nutrient-poor or "empty calories" (11).

To help assess the nutritional quality of total diets, several nutrient profiling systems or nutrition quality indexes have been developed and validated or tested against measures of a diet quality, such as the USDA-derived Healthy Eating Index (HEI) (21, 24–27). Most current tools for nutrient profiling and derivation of indexes of diet quality are based on a combination of nutrients to encourage and nutrients to limit (21, 25). For example, the Nutrient-Rich Foods 9.3 index is based on 9 nutrients to encourage (calcium, magnesium, potassium, fiber, protein, iron, and vitamins A, C, and E) and 3 to limit (saturated fat, added sugars, and sodium) per reference amount consumed (25). The Nutrient-Rich Foods 9.3 index also assigns equal positive or negative weight to nutrients because of a lack of clear scientific consensus to quantify the strength of an association between single nutrients and health. In contrast, other indexes use algorithms that incorporate proprietary nutrient weighting representing the relative effect of a nutrient on the basis of the prevalence and severity of health problems or conditions that are associated with inadequate or excess consumption of certain nutrients (27).

More recently, a nutrient profiling approach was devised by using the Weighted Nutrient Density Score, which is based on 7 nutrients (protein, unsaturated fat, fiber, calcium, vitamin C, saturated fat, and sodium) and added sugars that best explain the largest proportions of variance in 2005 HEI scores (28). The Weighted Nutrient Density Score algorithm may be a tool that can be used to approximate the nutrient quality of individual foods as long as its limitations are recognized (28). The researchers acknowledge that the selection of nutrients in their model may change as new evidence influencing future guidance becomes available (28). For example, the recent revision of the DRI for sodium (29) to 2300 mg/d, which is less restrictive than the 2005 DRI for this nutrient (1500 mg/d), could influence scores in future iterations of the model. Foods that are excellent or good sources of protein, such as cheese, which also contains sodium, may have a better HEI score. Likewise, emerging opinion that calls into question current recommendations to reduce saturated fat intake to lower the risk of cardiovascular disease (30, 31), along with recent recommendations for adjustment in national dietary guidelines, in Sweden for example, toward lower-carbohydrate (higher-protein) diets to reduce risk of obesity, diabetes, and heart disease (32), could potentially result in more favorable scores for protein foods that contain saturated fat (e.g., full-fat dairy foods, some higher-fat meats). The researchers also recognized that their model needed to be updated by using the modified 2010 HEI instead of the 2005 HEI (28). The 2010 HEI scoring system includes several changes from the 2005 HEI (33, 34). For example, seafood and plant proteins, which represent selected subgroups of protein foods, as well as refined grains, have been added to the 2010 HEI.

## PROTEIN FOODS AND THEIR CONTRIBUTION TO NUTRIENT INTAKE AND DIET QUALITY

As shown in **Figure 1A**, with data from NHANES 2007–2010, the protein foods group, which contains both animal- and plant-based protein foods, makes a substantial contribution to the daily



**FIGURE 1** Mean ( $\pm$ SEM) dietary intake data from NHANES 2007–2010 (VL Fulgoni, unpublished observations, 2014) for both men and women aged  $>19$  y ( $n = 11,296$ ). A–C: Contribution of the protein foods group (animal and plant sources) (A), the meats category of foods (B), and plant-based foods (C) to percentages of daily intakes of various nutrients. Note differences in axis scaling between graphs. DFE, dietary folate equivalents.

intake of a number of nutrients, including nutrients of concern. Animal-based protein sources such as meats contribute more protein and several nutrients (e.g., zinc, vitamin B-12, phosphorus,

and iron) than do plant-based protein foods; however, plant-based protein foods can contribute more of other nutrients (e.g., dietary fiber, vitamin E, magnesium; Figure 1B, C). These data support the advice to consume a variety of protein food sources, both animal- and plant-based, to help meet nutrient recommendations.

In addition to examining the nutrient contribution of broad categories of animal- and plant-based food sources of protein, researchers, with the use of dietary intake data from NHANES, showed that the consumption of specific protein-containing foods contributes to greater intakes of many nutrients, including nutrients of concern (8, 18). For example, lean beef and pork are among the top food sources not only of protein but also of key nutrients in Americans' diets (34–36). By using 24-h dietary recall data for adults ( $n = 13,292$ ) participating in NHANES 1999–2004, researchers found that the consumption of lean beef ( $<9.3$  g fat/100 g, after cooking) provided 14–15% of total protein intake and was a source of nutrients of concern, including vitamin B-12, iron, and potassium, while contributing  $<4\%$  of total energy, total fat, or saturated fat intake (36). A recent study reported the association between beef consumption, in its lowest- and highest-fat forms, and nutrient intake, diet quality, and food patterns in individuals participating in NHANES 1999–2004 (35). Compared with non-beef consumers, those who consumed the highest quantities of lean beef had significantly higher intakes of protein (91 compared with 78 g) and nutrients of concern, including vitamin B-12, potassium, and iron. In addition, lean beef consumers had higher intakes of other nutrients such as vitamin B-6 and zinc (35). When nutrient intakes of beef consumers whose beef intake was “low fat” or “higher fat” were compared, consumers of low-fat beef had significantly higher intakes of protein, vitamin B-6, vitamin B-12, magnesium, iron, zinc, and potassium, as well as lower intakes of total energy, total fat, saturated fat, monounsaturated fat, and carbohydrates, and better diet quality, as defined by 2005 HEI scores, than did consumers of higher-fat beef (35).

Pork and pork products were also shown to be important sources of protein, accounting for 27% and 23% of total protein consumption, respectively (37). In addition, pork contributed other key nutrients consumed by adults (e.g., selenium, thiamin, phosphorus, potassium, riboflavin, niacin, vitamin B-6, and vitamin B-12), although contributed a relatively small amount to total energy intakes (i.e., 10% and 7% of total energy for fresh pork consumers and fresh lean pork consumers, respectively) (37).

Plant-based protein sources identified in the MyPlate protein foods group (23) such as nuts and beans are less commonly consumed sources of protein than animal sources; however, their consumption can also improve nutrient intake and/or dietary quality according to studies that used data from NHANES (38–40). For example, compared with non-nut consumers, those consuming tree nuts were shown to have improved nutrient intakes, including nutrients of concern (i.e., fiber, calcium, and potassium), and a better diet quality as reflected in 2005 HEI scores (38, 39). Interestingly, despite the fact that tree nuts also have a relatively high fat content, tree nut consumers had body weights, waist circumference, and obesity incidence similar to nonconsumers (38). Importantly, high tree nut consumption was also associated with improved markers of health (38). Also, consumers of beans (e.g., variety beans, baked beans) had better overall nutrient intakes than did nonconsumers, including higher intakes of fiber, potassium, magnesium, and iron (40).

Although the milk and dairy foods and the breads, rolls, and tortillas categories are not included in the MyPlate protein goods group, these protein food sources contribute to adults' nutrient intake (18; **Figure 2**). The milk and dairy group, a source of animal protein, contributes more protein and more of several nutrients (e.g., vitamin D, calcium, vitamin B-12, vitamin A, phosphorus) to adult diets than do the breads, rolls, and tortillas category, a plant-based source of protein (Figure 2). However, the breads, rolls, and tortillas category makes a greater contribution to adults' intake of other nutrients (e.g., thiamin, folate, iron, dietary fiber) than does the milk and dairy group. Again, these findings support the recommendation to consume a variety of protein food sources, both animal- and plant-based.

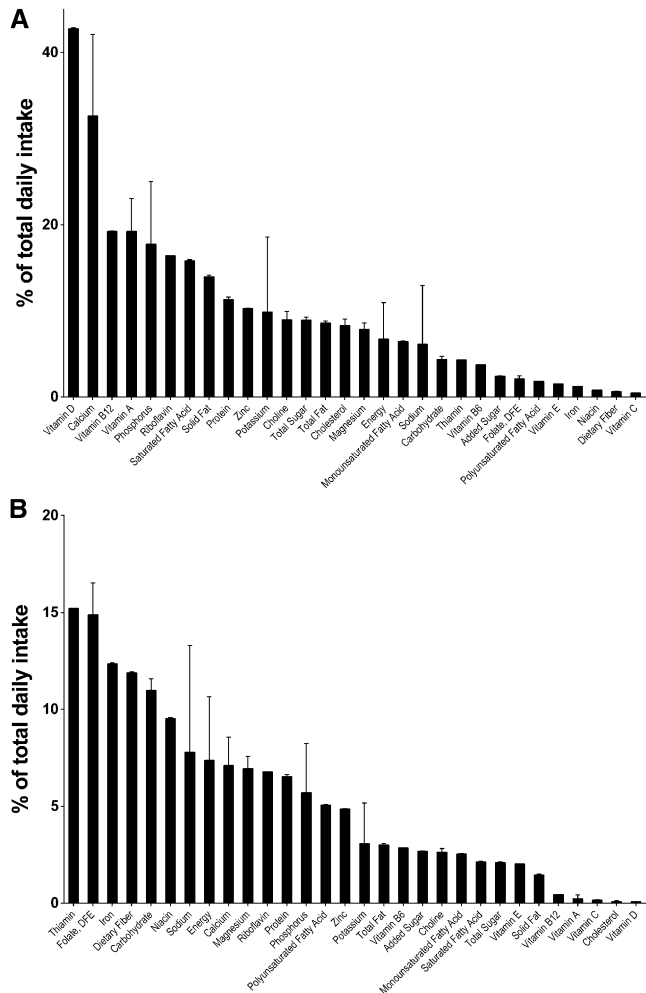
Dairy foods are an important source not only of high-quality protein but also of 3 nutrients of concern—calcium, vitamin D (when fortified), and potassium—in the American diet (18, 41). Even at current dairy consumption amounts, which fall short of daily recommended intakes (i.e., 1.7 compared with 3 servings), dairy foods provide 18% of total daily protein intake, 51% of total daily calcium intake, 58% of daily vitamin D, and 16% of

daily potassium intake, according to NHANES 2003–2006 data for individuals aged  $\geq 2$  y (41, 42). In addition, dairy foods contributed to intakes of other nutrients such as vitamin A, phosphorus, vitamin B-12, riboflavin, zinc, and magnesium at only 10% of the daily energy intake in Americans' diets (42). The 2010 DGA advisory committee (10) used consumption models of foods and considered their nutrient contributions to develop intake recommendations for each group. Results of their estimations showed that 3 servings of milk or dairy foods would contribute  $\sim 12\%$  of the energy in a 2000 kcal/d diet and  $>70\%$  of the recommended calcium and vitamin D; between 30% and 40% for each of vitamin A, riboflavin, and vitamin B-12; and between 20% and 30% for each of protein, potassium, zinc, and choline.

Increasing average dairy consumption by 1 more cup of milk or serving of yogurt per day could help close nutrient gaps, for 3 nutrients of concern (calcium, vitamin D, potassium), according to a study that used 2 modeling approaches, one based on USDA's MyPyramid food patterns and another on 2003–2006 NHANES data from 16,822 individuals (43). Germane to the focus of this article, daily protein intake increased or decreased by  $\sim 8$  g with the addition or removal of 1 serving of dairy. If dairy foods were completely removed from the diet without a reasonable replacement, then the daily intake of protein would be decreased by 25 g and intake of other essential nutrients such as calcium and vitamin D would be lower (43). Furthermore, if dairy foods were replaced with calcium replacement foods such as calcium-fortified juices, substantial changes to most diets would be necessary to meet recommendations for nutrients such as magnesium, phosphorus, potassium, and protein (43).

In general, the elimination of or substantial reductions from a person's diet in a food or food group could potentially result in unintended consequences with respect to nutrient intakes unless compensatory changes are made (8). For example, cheese, beef, and milk are among the top 4 sources of dietary saturated fat (18). Nonetheless, despite recommendations to reduce saturated fat intake, these same foods are among the top food sources of protein (Table 1) and contribute  $>40\%$  of vitamin B-12, almost half of the vitamin D and calcium, and other essential nutrients in the American diet (8). For this reason, reduced-fat cheese, lean beef, and fat-free or low-fat milk are recommended instead of their higher-fat counterparts (11).

Intakes of total, animal, and plant proteins or food sources of proteins from specific animal and plant sources and how they affected diet quality with the use of the Probability of Adequate Nutrient Intake Diet (PANDiet) index, a diet quality score based on 24 nutrients (44), were studied in French adults (45). The intake of animal protein was the main contributor (69.5%) to total protein intake. Meat and dairy products were the 2 principal contributors to animal protein intake, and cereals were the most important contributor to plant protein intake. Although the intake of plant protein was positively associated with diet quality and hence a healthy diet, the association between animal protein and nutrient adequacy varied according to specific sources of animal protein. Nutrient-dense animal protein foods such as fish, milk, and yogurt were positively associated with the PANDiet score, whereas intakes of processed meat, cheese, and eggs were inversely associated with the PANDiet score (45).



**FIGURE 2** Mean ( $\pm$ SEM) dietary intake data from NHANES 2007–2010 for both men and women aged  $>19$  y ( $n = 11,296$ ). A, B: Contribution of milk and dairy foods (A) and breads, rolls, and tortillas (B) to percentages of daily intakes of various nutrients. Note differences in axis scaling between graphs. DFE, dietary folate equivalents.

## IMPACT OF COMMONLY CONSUMED DIETARY PROTEIN PATTERNS ON NUTRIENT ADEQUACY

Despite recommendations to consume nutrient-dense foods, it is recognized that the typical diet of Americans (and many “industrialized” societies) falls short of food-based guidance, and Americans do not consume the most nutrient-dense forms of foods (11, 12). By using food modeling analyses, it was shown that food patterns that include typically consumed instead of nutrient-dense food choices may meet nutrient requirements but often exceed intakes for a number of nutrients that should be limited, in particular energy intake (10, 47). With the use of USDA food patterns at 12 energy amounts with nutrient profiles based on NHANES 2003–2004, researchers found that if Americans consumed the recommended amounts from each food group, but chose foods that are typically consumed as opposed to nutrient-dense foods, then goals for intakes of nutrients were not substantially different but intakes greatly exceeded recommendations for total fat, saturated fat, and sodium (47). Importantly, making typical instead of nutrient-dense food choices resulted in the consumption of excess energy which, given the current high prevalence of overweight and obesity, is concerning. Thus, a failure to consume nutrient-dense foods, including nutrient-dense protein foods, makes it more difficult to meet the goals for USDA Food Patterns (46) or the 2010 DGA (11).

The 2010 DGA advisory committee called for a shift to a more plant-based diet but recognized that animal products provide greater quantity and quality of protein than do plant foods (10). The higher energy intake to achieve adequate protein intake from plant foods needs to be considered, especially those with lower energy intakes and specific nutrient needs such as older adults (10). By using food pattern modeling analysis, the effect of plant-based (lactoovovegetarian diets with 50% of all protein from plant foods) or vegan food patterns on nutrient adequacy has been examined (10). In general, plant-based, lactoovovegetarian, and vegan food patterns met almost all of the goals for nutrient adequacy on the basis of the DRIs (3) and 2010 DGA (11). Amounts of protein in all dietary patterns were above the RDA; however, overall protein amounts decreased with increasing amounts of plant products in the patterns. It was concluded that USDA food patterns can be adapted with limited effects on nutrient adequacy for individuals who want to consume more or only plant-based diets (10). Importantly, however, if individuals choose typical plant-based diets without including foods fortified with vitamin B-12, vitamin D, and calcium, intakes of these nutrients may be inadequate (10). In addition, the bioavailability of some nutrients in plant-based dietary patterns or food sources of protein is generally lower than that of animal-based patterns, which needs consideration. For example, the relative bioavailability of iron from vegetarian diets is lower than that from omnivorous diets (10). The presence of components such as phytates in plant foods can negatively affect the bioavailability of nutrients such as calcium (48) and protein (49).

## CONCLUSIONS AND RESEARCH GAPS

Determination of the optimal amounts and ideal types of protein-containing foods to help achieve nutrient adequacy is an area of research interest, especially considering that many Americans are overweight or obese and some are undernourished

(11). Also, Americans’ diet quality is far from optimal as measured by indexes such as the 2010 HEI (12). Although several observational studies investigated the effect of nutrient-dense protein foods on nutrient intake and diet quality in adults (35–41), few studies directly examined the impact of commonly consumed protein foods on nutrient adequacy. Further evidence is required to show not only that higher protein intakes are beneficial for health variables but also that higher protein intakes come closer to meeting nutrient needs without exceeding energy requirements. More research is also needed to determine the impact of protein food sources on nutrient adequacy in children and adolescents, as well as the consequences of consuming plant-based diets on nutrient adequacy in vulnerable populations such as older adults. Another unknown is the impact on sources of protein intake because recommendations to consume lower-carbohydrate (higher-protein) diets are being increasingly advocated (32) over low-fat, low-saturated-fat diets to reduce the risk of chronic diseases. An emerging area that requires additional knowledge is how the use of DIAAS and the treatment of individual amino acids as nutrients might affect protein requirements and recommendations.

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