Protein Quality Guide

All proteins are not created equal

AMERICAN
Dairy Products
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Protein & Amino Acids

Protein is an essential nutrient required by our body every day. **Amino acids**, the building blocks of proteins, provide the structural components needed for a number of critical body functions such as maintaining a strong musculoskeletal system and healthy immune function, transporting oxygen to muscles, and aiding the metabolism of other nutrients. When discussing amino acids, there are two main categories: essential or indispensable and non-essential or dispensable.

The food in our diet must supply a sufficient amount of essential amino acids each day in order to keep us healthy and for all of our body systems and tissues to function properly. Twenty amino acids are needed for the body to make protein. Eleven non-essential amino acids (NEAA) can be made by the body. Nine essential amino acids (EAA) are not made by the body and must be provided by the diet. EAAs – in particular the three branched-chain amino acids (BCAA) of leucine, isoleucine and valine – play unique roles in our bodies. Leucine, in particular, stimulates and supports protein synthesis. Insufficient intake of EAAs will compromise the ability of muscle tissue to grow, repair and to be maintained. Dairy proteins are a rich source of EAAs and BCAAs.

Determining Protein Quality

Protein quality is the ability of a food protein to meet the body's metabolic demand for amino acids and nitrogen. The factors needed to determine a protein quality score are: amino acid composition, digestibility of EAAs, and the EAA requirements of the target population. A higher concentration of EAAs in a given food is one of the main indicators of protein quality: **higher concentration = higher quality.**

A **complete protein** is a dietary protein that has all the EAAs in sufficient quantities needed by the body. Complete protein sources include fish, poultry, eggs, beef, pork, dairy, and soy foods like tofu or edamame. Figure 1 shows the EAA concentrations of various protein sources. The dashed line represents the EAA concentration in whey protein, the protein source most abundant in EAAs.

An **incomplete protein** is a dietary protein that lacks one or more of the EAAs and/or has them in insufficient amounts. Vegetables, whole grains, seeds, nuts, and legumes (beans, peas, and lentils) are incomplete protein sources. Diets don't need to include only complete proteins to be beneficial. Plant protein sources with complementary amino acid profiles can be combined to make them a more complete protein source. Combining animal and plant protein sources helps to contribute more EAAs, as well as other important nutrients to the diet (e.g., fiber).

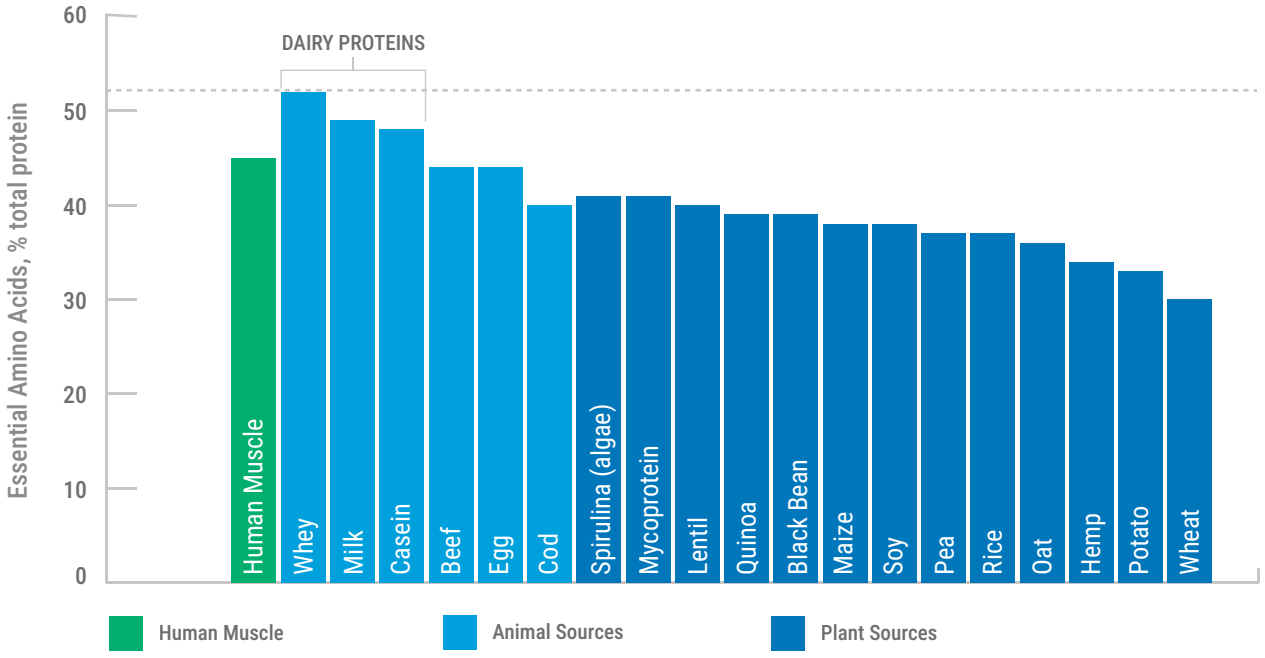

Figure 1: Essential amino acid concentrations of various protein sources (adapted from 10).

It is generally believed that leucine content of a protein source is an important predictor of its capacity to stimulate postprandial (after-meal) muscle protein synthesis (10). Figure 2 shows the leucine concentrations of different protein sources. The dashed line represents the leucine concentration in whey protein. A comparison of the different protein sources reveals that the leucine content of whey is highest, with 13.6%. Animal-based protein sources generally contain more leucine than do plant based proteins. Most plant-based sources have a leucine content of 6–8%, whereas animal-based protein sources tend to have a leucine content in the range of 8.5–9% and >10% in the case of dairy proteins.

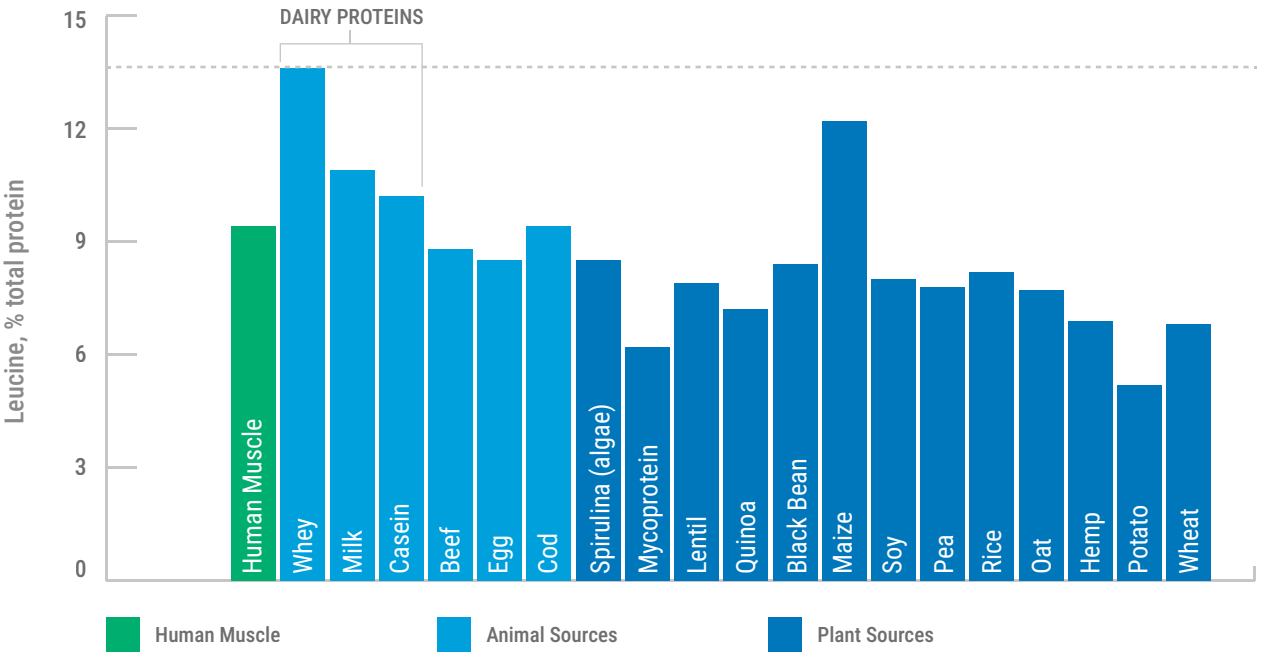

Figure 2: Leucine concentrations of different protein sources (adapted from 10).

Protein Quality Scores

The digestibility of a protein source has been defined as the proportion of dietary protein that is effectively digested and absorbed, thus becoming available in a form suitable for body protein synthesis. Animal-based protein sources including dairy, eggs and meat are highly digestible (>90%).

METHODS FOR PROTEIN QUALITY ASSESSMENT INCLUDE:

The **Protein Digestibility Corrected Amino Acid Score (PDCAAS)** is the current method of protein quality assessment used by the US Food and Drug Administration (FDA) for food labeling in the US. The **Digestible Indispensable Amino Acid Score (DIAAS)** is the newer model of protein quality assessment recommended by a panel of experts convened by the Food and Agriculture Organization (FAO).

PDCAAS is a measure of the total protein (fecal nitrogen) digestibility in the digestive tract (where 1.00 = 100%). It is said that PDCAAS values overestimate digestibility due to bacterial fermentation in the colon. For foods and ingredients where the PDCAAS values are greater than 1.00 (e.g., MPC, WPI), scores are rounded (truncated) to 1.00 (8). DIAAS, on the other hand, measures absorption of individual (indispensable/essential) amino acids (rather than nitrogen) in the ileum, the final section of the small intestine where amino acids are absorbed (8). As such, DIAAS is recognized as a more accurate assessment and is preferred in the scientific community (4, 8).

All proteins are not created equal (4), as shown by the protein quality scores for select protein ingredients and whole foods via the two different scoring methods (Table 1). Dairy proteins are the highest quality proteins available regardless of the scoring system used. The DIAAS model, because it is not truncated at 1.00, allows for greater differentiation between dairy and alternative proteins. Other factors influencing protein quality are the demands that are specific to the individual consuming the food such as age, health status, physiological status, and energy balance (2). Furthermore, affordability cannot be overlooked. Recently, Drewnowski (4) conducted an analysis to compare dairy with other protein-rich foods in terms of protein content and quality, nutrient density, and protein cost per 1-oz equivalent. Using USDA nutrient composition databases and published national food prices, and correcting protein quality using PDCAAS, it was demonstrated that dairy foods are nutrient-rich, provide affordable high-quality protein, and compare favorably with other protein-rich foods (e.g., pork, chicken, eggs, legumes).

TABLE 1: PDCAAS & DIAAS for ingredients and foods (adapted from 6, 8, 1).

FOOD	PDCAAS	DIAAS
Whole milk	1.00	1.43
Milk protein concentrate	1.00	1.18
Egg	1.00	1.13
Whey protein isolate	1.00	1.09
Whey protein concentrate	1.00	0.97
Tofu	0.70	0.97
Soy protein isolate	0.98	0.90
Pea protein concentrate	0.89	0.82
Chickpeas	0.52	0.67
Cooked kidney beans	0.59	0.65
Cooked rice	0.62	0.60
Cooked peas	0.58	0.60
Cooked rolled oats	0.67	0.54
Roasted peanuts	0.51	0.43
Almonds	0.35	0.40
Rice protein concentrate	0.42	0.37
Corn-based cereal	0.08	0.01
Hydrolyzed collagen	0.00	0.00

Both the digestibility and bioavailability of a protein are affected by the food matrix, which includes the levels and types of fat, carbohydrate and the presence of anti-nutritional compounds that can interfere with the digestion and absorption of the available protein (2). Depending on the processing method, and/or presence of various anti-nutritional factors, plant-based protein sources such as maize, oat, bean, pea and potato tend to exhibit lower digestibility than do animal sources, with values ranging from 45% to 80% (10). This means that less of the dietary protein is effectively digested and absorbed, resulting in lower postprandial (post-eating) availability of dietary protein–derived amino acids as precursors for muscle protein synthesis. However, purified plant-based proteins may possess digestion and absorption kinetics similar to animal-derived proteins once they are separated from anti-nutritional compounds that interfere with protein digestion and absorption (5).

Protein Quality Score and Product Labeling

How is protein quality translated for consumers? Most consumers tend to look for the quantity of protein on a product label but don't have an understanding of the quality of the protein. Figure 3 provides an illustration of how different sources of protein can impact a nutrition label. These nutrition labels represent two different protein drinks with the same protein content. One product contains only dairy protein and the other contains pea protein. Protein content can be represented on the label in two ways: the first, which is mandatory, is the absolute protein content in grams. Additionally, companies may choose to also include the % daily value (DV) that is met by consumption of one serving. PDCAAS is factored into the calculation for the % DV. Reporting a % DV is mandatory when a product label makes a protein claim such as "good source" (10 to 19% of the DV) or "excellent source" (at least 20% of the DV) or simply calls out the amount of protein in the product.

The corrected protein content is determined by multiplying the absolute protein content by the PDCAAS value. This number is then divided by 50 (the daily value for protein is 50 g/day for those aged 4+), to get the %DV. The %DV shows the corrected amount of a nutrient in one serving of the food. Nutrient content claims can be made using the %DV.

To calculate PDCAAS when total protein content and %DV are known:

1. %DV x 50 (daily value for protein) = corrected protein content

2. Corrected protein content / total protein content = PDCAAS

Dairy Protein Drink Label

Nutrition Facts

12 servings per container

Serving size **1 Carton (330mL)**

Amount per serving

Calories **130**

	% Daily Value*
Total Fat 2g	**3%**
Saturated Fat 0.5g	**3%**
Trans Fat 0g	
Cholesterol 15mg	**5%**
Sodium 240mg	**10%**
Total Carbohydrate 11g	**4%**
Dietary Fiber 2g	**7%**
Total Sugars 3g	
Includes 3g Added Sugars	**6%**
Protein 20g	**40%**

PDCAAS 1.0
Corrected protein content is 20 g

Plant Protein Drink Label

Nutrition Facts

1 serving per container

Serving size **1 Carton (330mL)**

Amount per serving

Calories **140**

	% Daily Value*
Total Fat 4.5g	**6%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 510mg	**22%**
Total Carbohydrate 8g	**3%**
Dietary Fiber 2g	**7%**
Total Sugars 0g	
Includes 0g Added Sugars	**0%**
Protein 20g	**30%**

PDCAAS 0.75
Corrected protein content is 15 g

Figure 3: Product labeling comparison of protein drinks with dairy vs. plant protein.

Consuming proteins of differing protein quality may also have a caloric impact, as a larger amount of a lower quality protein needs to be consumed to deliver similar EAA content as higher quality proteins. Figure 4 reflects the energy intake of different protein sources to meet minimal requirements of adults to obtain all EAAs. Whey protein requires the lowest caloric intake to meet the EAA requirements, while peanut butter requires the highest caloric intake. For people that are trying to manage their weight, it is especially important to choose high quality protein sources to help keep their caloric intake low. In a linear programming optimization research study, Cifelli et al. (3) found no reasonable non-dairy substitutes for the protein and shortfall nutrients provided by dairy because of the greater intake of energy (up to 8X more kJ) and higher cost (up to 6X more) required.

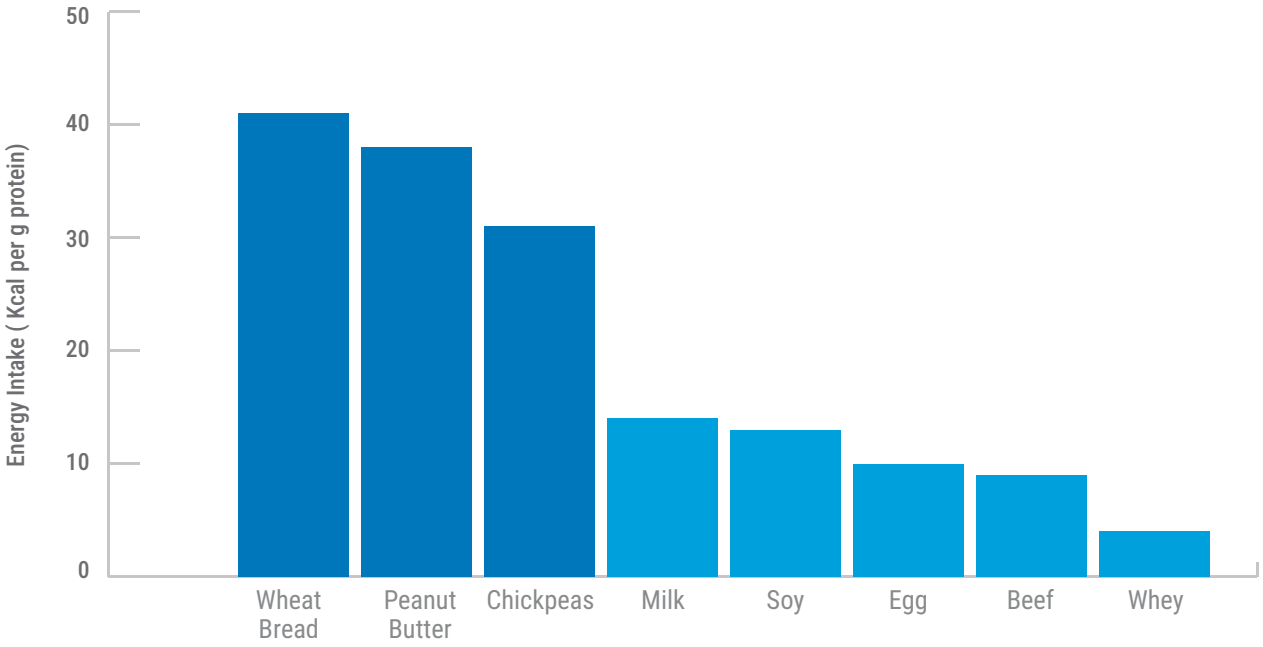

Figure 4: Energy intake of different protein sources needed to meet minimal requirements of adults for all essential amino acids (adapted from 11).

Recommended Protein Consumption

When looking at current protein consumption recommendations and how research is evolving to help shape these recommendations, it is important to understand the context and purpose for which they were developed. The Recommended Dietary Allowance (RDA) for protein consumption is 0.8 g/kg of body weight/day for healthy adults (roughly 7g of protein for every 20lb of body weight/day). This is based on the results from available studies that estimated the minimum protein intake to prevent deficiency as reflected by nitrogen balance.

There is also the Acceptable Macronutrient Distribution Range (AMDR), which along with the RDA, is established by the Food & Nutrition Board of the Institute of Medicine. The AMDR is defined as a range of intakes for a particular energy source that is associated with reduced risk of chronic diseases while providing adequate intakes of essential nutrients. For protein this range is set at 10 to 35% total energy intake (7, 12).

Research supports that athletes, highly active adults, older adults and those interested in weight management may benefit from protein intakes greater than the RDA. Translating these recommendations, a 70 kg (154 lb) male consuming 2,000 calories/day would consume 56 g protein/day to meet the RDA with an AMDR of 50-175 g protein/day. Athletes' suggested daily intake is 1.2 to 2.0 g protein/kg body weight/day or for a 150 lb person, ~82 to 136g protein/day (9). There are also recommendations for older adults over the age of 65. It is recommended that this age group consume 25-30 g of protein (2.5-2.8g of leucine) per meal in combination with resistance training to help maintain muscle mass.

Take-home Message

Not all protein-rich foods and ingredients contain equal amounts of protein, equivalent protein quality, or comparable micronutrient content and bioavailability. By providing a good to excellent source of high-quality, complete protein, composed of EAAs and BCAAs that we need for muscle development, muscle repair and overall health, dairy foods and dairy ingredients are superior to other protein-rich options.

References

1 Adhikari, S., M. Schop, I. J. M. de Boer, and T. Huppertz. 2022. Protein Quality in Perspective: A Review of Protein Quality Metrics and Their Applications. Nutrients. 14. https://doi.org/10.3390/ nu14050947.

2 Boye, J., R. Wijesinha-Bettoni, and B. Burlingame. Protein quality evaluation twenty years after the introduction of the protein digestibility corrected amino acid score method. Br J Nutr. 2012 Aug;108 Suppl 2:S183-211.

3 Cifelli, C. J., N. Auestad, and V. L. Fulgoni III. 2020. Replacing the nutrients in dairy foods with non-dairy foods will increase cost, energy intake and require large amounts of food: National Health and Nutrition Examination Survey 2011-2014. Public Health Nutrition. 25(2): 332-343.

4 Drewnowski, A. 2025. Perspective: Milk and dairy provide affordable high-quality protein and merit inclusion in the protein foods group. Current Developments in Nutrition. 9. https://doi.org/10.1016/j.cdnut.2024.104539.

5 Gorissen, S. H. M., A. M. H. Horstman, R. Franssen, J. J. R. Crombag, H. Langer, J. Bierau, F. Respondek, and L. J. C. van Loon. 2016. Ingestion of wheat protein increases in vivo muscle protein synthesis rates in healthy older men in a randomized trial. J. Nutr. 146(9): 1651-1659.

6 Phillips, S. M. 2017. Current concepts and unresolved questions in dietary protein requirements and supplements in adults. Front. Nutr. 4:13. https://doi.org/10.3389/fnut.2017.00013.

7 Rodriguez, N. R., and S. L. Miller. 2015. Effective translation of current dietary guidance: understanding and communicating the concepts of minimal and optimal levels of dietary protein. Am J Clin Nutr. 101(6): 1353S-1358S.

8 Rutherfurd, S. M., A. C. Fanning, B. J. Miller, and P. J. Moughan. 2015. Protein digestibility-corrected amino acid scores and digestible indispensable amino acid scores differentially describe protein quality in growing male rats. J. Nutr. 145(2): 372-379.

9 Thomas, D. T., K. A. Erdman, and L. M. Burke. 2016. Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance. J Acad Nutr Diet. 116(3): 501-528.

10 van Vliet, S., N. A. Burd, and L. J. C. van Loon. 2015. The skeletal muscle anabolic response to plant- versus animal-based protein consumption. The Journal of Nutrition. 145(9): 1981-1991.

11 Wolfe RR, Church DD, Ferrando AA and Moughan PJ. 2024. Consideration of the role of protein quality in determining dietary protein recommendations. Front. Nutr. 11:1389664. doi: 10.3389/fnut.2024.1389664

12 Wolfe, R. R., and S. L. Miller. 2008. The recommended dietary allowance of protein: a misunderstood concept. JAMA. 299(24): 2891-2893.

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