Improving quality and digestibility of plant proteins makes the body utilize protein in food products to the max

One could say that a primarily plant-based diet is healthier than a primarily animal-based diet. There are, however, some nutrients that easier acquired through an animal-based diet. These include calcium, vitamin B12 and protein. With an average daily requirement of 0,66 grams of protein per kilogram of body weight (g/kg BW) and an average intake of 0,83 g/kg BW (data from EFSA survey in 2012)[1], most people get more than enough protein. But there is a catch: plant proteins generally do not have the same level of quality and digestibility as animal proteins.

How protein quality is defined

Out of 21 common amino acids, nine are considered essential for humans while several others may only be essential under certain conditions. There are considered essential, because the body cannot synthesize them and therefore they must come from food intake. There are, however, two essential/conditionally essential amino acid pairs -methionine/cysteine and phenylalanine/tyrosine- where the body can convert the one into the other and therefore their recommended daily intake is pooled under 'essential amino acids'.

From earlier analysis of nitrogen balance studies, a reference content of essential amino acids has been determined [2]. This means that for the body to optimally utilize a protein source, it should have at least these amounts of essential amino acids (Table 1, first column). If one of these amino acids is present in lower amount, it is called 'the limiting amino acid' and it determines how much of the protein can be utilized. For example, if the content of histidine would only be nine milligrams per gram of protein instead of eighteen, half of the protein cannot be used by the human body.

Table 1. Dietary reference values on essential amino acid content of consumed protein and the measured amino acid content (both in mg/g protein), calculated amino acid score (AAS) and digestibility corrected amino acid score (DCAAS) based on 65% digestibility of a random plant-based food product.

	Reference amino acid content	Values on actual food product		
		Amino acid content	AAS	DCAAS
Histidine	18	22	1,22	0,79
Isoleucine	25	39	1,56	1,01
Leucine	55	73	1,33	0,86
Lysine	51	38	0,75	0,48
Methionine & Cysteine	25	52	2,08	1,35
Phenylalanine & Tyrosine	47	86	1,83	1,19
Threonine	27	33	1,22	0,79
Tryptophan	7	14	2,00	1,30
Valine	32	55	1,72	1,12

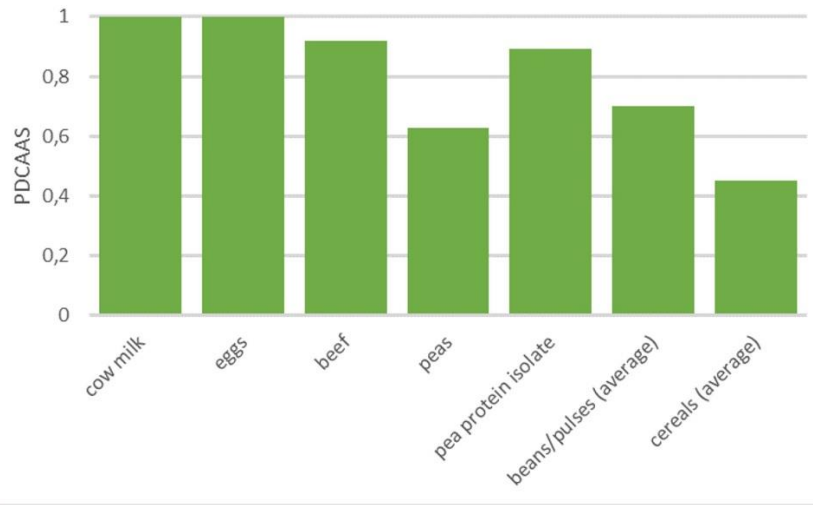
Protein qualities of food products

Food products mostly contain multiple proteins with varying amino acid compositions. The total protein quality (amino acid score, or AAS) of a food product is determined by measuring the essential amino acid content and comparing this with the reference values. In Table 1, columns 2 and 3, it is shown that for the given food product the contents of most essential amino acids are higher than the reference, except for lysine, that is only 75% that of the reference. Hence, lysine would be the limiting amino acid.

Additional to amino acid content, digestibility of a protein is also a factor that plays a role. In many cases, the protein in a food product is only partially digestible, for example through the presence of antinutrients such as protease inhibitors (that lower the activity of enzymes in the intestine that are responsible for digestion) and dietary fibers (that give a faster bowel movement allowing less digestion time). These are particularly important in plant-based food. To correct the AAS, the measured amino acids are multiplied by a factor representing what fraction of the protein is digested (65% in Table 1, column 4). Now the final protein quality (protein digestibility amino acid score, or PDCAAS) is the lowest value in the column, meaning that the content of lysine and the protein digestibility together make that the body can only utilize less than half of the protein.

Most animal proteins score high in PDCAAS, meaning that they both have sufficiently high contents of essential amino acids and the products they are in are easily digestible. For example, cow milk and eggs have a PDCAAS of one (the maximum value as higher calculated values are cut off at one), whereas that of beef is 0,92 (Figure 1). Plants generally have lower PDCAAS because they are low in one more essential amino acids and/or are more difficult to digest. Isolating the protein generally increases the PDCAAS by reducing antinutrients (see for example pea versus pea protein isolate in Figure 1).

Figure 1. Protein digestibility corrected amino acid score (PDCAAS) of several food products

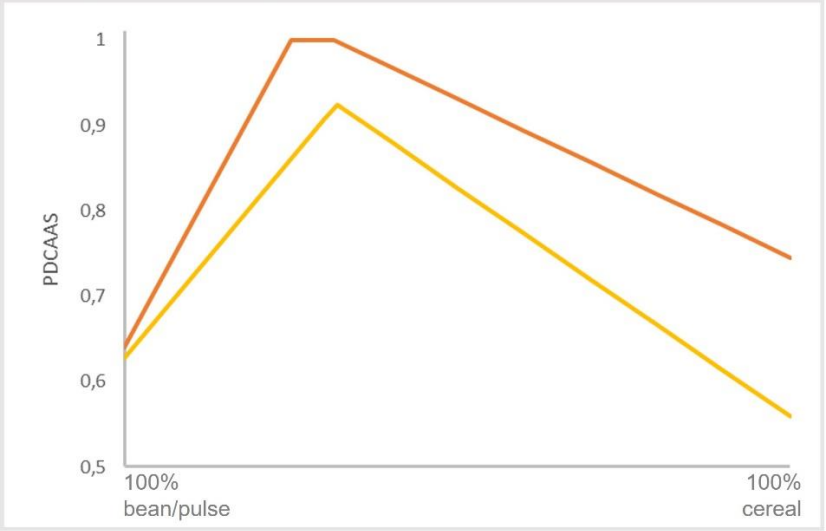


Protein quality improvement by blending sources and increased digestibility

Where protein quality is challenged by the low presence of one or more essential amino acids, it is possible to improve quality by blending sources. It is a general trend that cereals are low in lysine whereas beans and pulses are low in sulfur amino acids methionine and cysteine, leading to low PDCAAS in both food products. By combining them in the right ratio in a meal, or in a single food product, the total protein quality increases (Figure 2, yellow).

Further improvement may then come from increased digestibility, for example by removing antinutrients, partial hydrolysis or improving availability in the food matrix. This gives higher PDCAAS for the single ingredients already, but still, they do not reach the maximum score of one. By combining two ingredients and increasing digestibility, there is a range at which the protein quality is optimal and has a value of one (Figure 2, orange). Thus, by performing smart combinations of protein containing plant ingredients and the right processing steps, it is possible to make plant-based products that are at least on par with animal-based ones when it comes to the optimal protein quality and digestibility.

Figure 2. Protein digestibility corrected amino acid score (PDCAAS) of blends of cereals and beans/pulses without (yellow) and with (orange) optimized digestibility.



Brannatura develops recipes, processes and ingredients for plant-based food products, often containing cereals and beans or pulses. We are also experts in optimizing protein quality and increasing digestibility for optimal nutrition. Recipes and ingredients can be adapted to the customer's needs and we are happy to develop products together.

[1] Scientific Opinion on Dietary Reference Values for protein - - 2012 - EFSA Journal - Wiley Online Library

[2] 10 Protein and Amino Acids | Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids | The National Academies Press (nap.edu)