

Biological Value

Protein quality calculated, not estimated

Protein quality

In search of the best quality proteins consumers often do not know how to evaluate protein quality. First of all, the content of essential amino acids is crucial. As well as their bioavailability to the body for protein synthesis in order to build up or regenerate muscles. Each protein consists of amino acids, which are bound together in chains of different length. Amino acids are divided in 8 essential ones, which cannot be formed by the body itself and therefore have to be provided by our diet. There are also some semi-essential amino acids, which become essential under certain conditions (e.g. during childhood, after injuries, high-intensity physical activity). Lastly, there are non-essential amino acids, which can be formed by the body from essential amino acids depending on its needs. In conclusion a high content of essential amino acids defines a high-quality protein to a great extent. Such proteins are egg, whey, and also wheat to some extent. Soy and casein (cheese protein) have a less advantageous amino acid profile. But casein offers a very long absorption time due to its gel-forming properties during digestion, making it the ideal overnight protein source. Furthermore it is possible to combine different proteins in order to improve the overall amino acid profile.



Biological Value (BV)

To assess protein quality there are various chemical and biological methods. The most well-known is the Biological Value. The classic definition refers to the researcher THOMAS and means the amount of body protein in g, which is synthesized from 100 g of absorbed dietary protein. Whole egg protein gets a value of 100 with this method. But such results are only based on animal studies. Simply because you cannot engage humans for days or even weeks and feed them just protein like it is done with rats.

For this reason there is the possibility to calculate the BV with a method developed by the researcher OSER. It is the most accurate method to calculate protein quality with chemical analysis. After analysing the amino acids of a protein preparation, you calculate the so-called Essential Amino Acid Index (EAA-Index), which then is used in the formula to calculate the BV.

$$\text{EAA-Index} = \sqrt[n]{\frac{\text{Ile}_T}{\text{Ile}_R} \times 100 \times \frac{\text{Leu}_T}{\text{Leu}_R} \times 100 \times \frac{\text{Lys}_T}{\text{Lys}_R} \times 100 \times \dots}$$

T = test protein, R = reference protein, n = number of amino acids

$$\text{BW (ref. to OSER)} = (\text{EAA-Index} \times 1,09) - 11,7$$

It is supposed that the ideal amino acid profile for muscle build-up is similar to the one for 2-5 year old children¹. Using this amino acid profile as the reference protein leads to a BV of 155 for whole egg. Another advantage of this BV calculation method is the inclusion of the absolute protein content of a product. A protein preparation with 90% protein content will achieve a higher BV than one with only 70% protein with the same amino acid profile. This explains, why blends of free amino acids (cf. EAC amino tablets), which can be combined freely and normally are highly concentrated, can reach an extreme high BV. In contrast, the "ideal" reference protein's profile only reach a BV of 97, because there is no overdosage, but a theoretical deduction for digestibility. Please refer to the table below:

¹ Human amino acid requirements: a re-evaluation. Phys Human Nutr, 17(3):191-203

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Amino acids (mg/g pure protein)	Ideal reference protein (2-5 y of age)	Whole egg	Whey Colostrum (Peach-Vanilla)	EAC
Histidine	19	22	27.3	51.5
Isoleucine	28	54	69.5	77.8
Leucine	66	86	116.5	222.2
Lysine	58	70	97.5	109.8
Methionine + Cystine	25	57	47.9	135.8
Phenylalanine + Tyrosin	63	93	91.2	190.3
Threonine	34	47	55.6	75.9
Tryptophane	11	17	23.2	19
Valine	35	66	70.1	92.1
BV (ref. to OSER)	97	155	185	284

These values must not be confounded with the above mentioned classic definition of the Biological Value (ref. to THOMAS), of course. You cannot build up 180 g of body protein with only 100 g of absorbed protein. **But the calculated BV (ref. to OSER) permits the direct comparison of different protein preparations on the market, by opposing their amino acid profiles to the ideal reference amino acid profile.** The calculated BV of some SPONSER protein products is as follows:

- Whey Colostrum = 185
- Multiprotein 180 = 180
- Whey Protein 94 / Whey 94 CFM = 170
- Aminoforce (powder) = 166
- Aminoforce (chewing tablets) = 157
- EAC Amino tablets = 284

Obviously, there are other factors which should be considered before buying a protein preparation. For example the timing of ingestion, dwell and digestion time of a protein, or specific situations like wound healing, infect prophylaxis, glycogen supercompensation, intolerances and allergies. It is possible, that a wheat protein hydrolysate may be more appropriate when looking for a high natural glutamine content – or because it fits a vegetarian lifestyle and/or is free of lactose and milk protein – even though it has a relatively low BV.

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Critical view on the Biological Value (BV)

The BV given on any protein source or protein supplement is always based on literature values from previous animal studies with a reference protein of the same type. Such studies are not undertaken anymore these days. If you find a BV of 104-110 on a whey protein for example, this represents not the true BV of the very ingredient, but the literature value of the previous examination of a whey protein on rats. This is certainly somewhat irritating, when thinking about the various manufacture technologies, which influence the native properties of proteins to the good or the bad. Bioavailability of proteins is influenced by processing steps like e.g. ion exchange, acid precipitation, micro- and ultrafiltration, spray-, drum-, or freeze-drying, and so on. Especially because glycomacropetides and other co-factors become denatured if not gently treated during manufacture processing. Since quite some years there is e.g. whey protein on the market, which is manufactured by microfiltration. Such protein is undenatured in its structure. There are clear hints, that this supports anabolic effects in the metabolism beyond its pure amino acid profile and nutrition value thereby accelerating muscle build-up and recovery.

Obviously, such properties can only be examined with biological animal trials. In consequence, the indication of the classic BV on an ingredient or a finished protein preparation is not an exact value for that very product, but only the estimation based on previous examinations only permitting to classify different protein sources in relation to each other. Furthermore, as soon as various proteins are blended together, you find indeed BVs for some classical combinations like e.g. 136 (ref. THOMAS) for a mix of 64% potatoes + 36% whole egg. But how does this BV change when the mix ratio is changed? You only can guess by considering the individual amino acid profile and balancing low contents of single amino acids with different protein sources.

Seen these details it becomes clear, why the calculation of the BV referring to OSER by means of analysing the amino acid profile of the finished product is more correct and straightforward. Protein preparations on the market – also finished blend products, not just mono-preparations or ingredients – can be opposed to and compared with the ideal amino acid profile (reference protein).

Other methods of protein quality assessment

Chemical Score (CS)

The CS is based on the calculation of the limiting amino acid in the test protein. The contents of essential amino acids in the test protein are compared with the reference protein. The amino acid with the biggest deficit, i.e. falling low in content compared to the reference, is classified as the limiting one. So you can calculate a CS of each amino acid, but only the one of the limiting amino acid is really used and constitutes the CS of the whole protein.

$$\text{chemical score} = \frac{\% \text{ einer AS im Testprotein}}{\% \text{ dieser AS im Referenzprotein}}$$

AS = amino acid

If you take wheat protein as the test protein and compare it with whole egg, then lysine turns out to be the limiting amino acid since it is very low in wheat. Wheat contains only 40% as much lysine as whole egg, which results in a CS of 40. Often this is equated with a Biological Value (ref. to THOMAS) of 40. It is a suitable, but actually not correct approximation. Nor-

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mally also with this method the amino acid needs of 2-5 year old children should be taken as the reference protein. Taking gelatine for another example, the lack of tryptophane causes a virtual 0 as CS. Though, the intake of gelatine in form of a collagen hydrolysat normally follows other purposes than muscle build-up. It is the easiest and mostly used method, yet not very meaningful.

Protein Digestibility Corrected Amino Acid Score (PDCAAS)

Building on the CS is the calculation of the PDCAAS, giving the CS with consideration of digestibility. The formula is simply multiplying the CS with a digestibility value (e.g. 0.95). There is again one hitch, insofar as the digestibility should have to be defined from animal studies. But in praxis again only literature values of reference proteins are used! Consequently the same provisos like for the classic BV apply.

Protein needs recommendations

Daily protein needs are very individual and should be based on body weight and the physical activity level. It is a common misconception that endurance athletes need less protein than strength or speed athletes. In fact, primarily the activity level and intensity of muscular effort is decisive. The given recommendations in the box below are considering this:

Protein needs	
1.2-2.0 g per kg body weight Depending on activity level	Of the calculated protein needs, subtract the proteins ingested in your daily diet (≈ 1 g/kg body weight).
Source: Swiss Forum for Sport Nutrition, www.sfsn.ethz.ch	

When supplementing with protein you should deduct from your needs the protein amount already ingested with your daily diet. According to the 4th Swiss Nutrition Report the average dietary protein amount corresponds to about 1 g per kg of body weight and day. Therefore, a highly active athlete of 80 kg body weight, with a need of up to 160 g protein per day, already ingests about 80 g from a dairy and meat containing diet. Consequently, additional protein of about 80 g from supplements is enough.

