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Medical laboratory science
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Question
1. WHAT DO YOU UNDERSTAND BY THE TERM ''BIOLOGICAL VALUE OF PROTEINS"
2. LIST AND EXPLAIN THE VARIOUS METHODS OF ASSESSMENT OF PROTEIN QUALITY.

Answer

1. Biological value (BV) is a measure of the proportion of absorbed protein from a food which becomes incorporated into the proteins of the organism's body. It captures how readily the digested protein can be used in protein synthesis in the cells of the organism. Proteins are the major source of nitrogen in food. BV assumes protein is the only source of nitrogen and measures the proportion of this nitrogen absorbed by the body which is then excreted. The remainder must have been incorporated into the proteins of the organisms body. A ratio of nitrogen incorporated into the body over nitrogen absorbed gives a measure of protein "usability" – the BV.

Unlike some measures of protein usability, biological value does not take into account how readily the protein can be digested and absorbed (largely by the small intestine). This is reflected in the experimental methods used to determine BV.

BV uses two similar scales:

The true percentage utilization (usually shown with a percent symbol).

The percentage utilization relative to a readily utilizable protein source, often egg (usually shown as unitless).

These two values will be similar but not identical.

The BV of a food varies greatly, and depends on a wide variety of factors. In particular the BV value of a food varies depending on its preparation and the recent diet of the organism. This makes reliable determination of BV difficult and of limited use — fasting prior to testing is universally required in order to ascertain reliable figures.

BV is commonly used in nutrition science in many mammalian organisms, and is a relevant measure in humans. It is a popular guideline in bodybuilding in protein choice.

Biological value is determined based on this formula.[4][5]

$BV = (Nr / Na) * 100$

Where:

Na = nitrogen absorbed in proteins on the test diet

Nr = nitrogen incorporated into the body on the test diet

2. METHODS OF ASSESSMENT OF PROTEIN QUALITY:

1. Bioavailability
2. Amino acid profile
3. Net protein utilisation
4. Protein efficiency ratio
5. Net protein ration
6. Relative nutritive value
7. Nitrogen balance index
8. Tissue regeneration
9. Microbiological assay
10. Plasma amino acid

1. Bioavailability
Biological Value (BV), Net Protein Utilisation (NPU), and Nitrogen Balance (NB) rate proteins based on nitrogen measurements. They measure how much nitrogen people excreted, calculate how much protein that represents, and compare this number to how much protein was ingested. In such a way, they determine the protein's bioavailability.
All three scales are based on two assumptions, both of which have been challenged: first, that dietary protein is the body's sole source of nitrogen; second, that all nonexcreted protein has been used to make bodily proteins. In truth, some of the protein we ingest can be converted to glucose, especially if the protein's digestion is fast and the body's glycogen stores are low, and some can be fermented by our microbiota, especially if the protein's digestion is slow.
The BV scale is still in use today, though mostly in promotional material and in the media, and so it needed mentioning despite being outdated. The current official scale, used notably by the FDA, is the Protein Digestibility Corrected Amino Acid Score (PDCAAS), which takes into account not just the bioavailability of a protein but also its amino acid profile.

2. Amino acid profile
Proteins are composed of amino acids, some of which your body can synthesize and others not. The ones you need yet cannot synthesize, and thus need to ingest, are called essential amino acids (EAAs). Among those, branched-chain amino acids (BCAAs) are crucial to your muscles, with leucine being especially anabolic.

Amino acids: requirements of adults and contents of proteins

Amino acid	mg/kg/day*	mg/g of protein				
	Requirement		Milk	Pea	Rice	Soy	Whey
Histidine	10	15	30	17	24	26	21
Isoleucine	20	30	50	54	40	43	59
Leucine	39	59	97	97	88	80	116
Lysine	30	45	80	83	33	60	102
Methionine	10	16	27	5	29	10	23
Cystine	4	6	9	14	17	12	20
Methionine + cysteine	15	22	30	8	39	14	36
Phenylalanine + tyrosine	25	30	99	94	111	90	66
Threonine	15	23	47	43	38	37	76
Tryptophan	4	6	13	11	14	13	20
Valine	26	39	58	81	55	44	58

* Milligrams (of a given amino acid) per kilogram (of body weight) per day

Sources: *Protein and Amino Acid Requirements in Human Nutrition*, page 245, table 49 (World Health Organization, 2007); Douglas Kalman, "Amino acid composition of an organic brown rice protein concentrate and isolate compared to soy and whey concentrates and isolates" (*Foods*, 2014 Jun); Stefan Gorissen et al., "Protein content and amino acid composition of commercially available plant-based protein isolates" (*Amino Acids*, 2018 Aug); USDA Food Composition Databases (accessed: 2018 Sep)

A protein is called complete when, proportionally to its overall amino-acid content, it has enough of each EAA (as shown in the “mg/g of protein” column in the above table). The main advantage of animal proteins is that most are complete.
Most, but not all. Take beef protein powders: you might assume they’re made from meat, which is to say from the animal’s muscles, when most are actually made from collagen boiled from the animal’s skin, bones, and other connective tissues. Now, dietary collagen is far from useless; it’s been shown to promote skin and joint health, and it probably promotes bone health too; but it isn’t a complete protein. Rich in glycine and proline but poor in BCAAs, it isn’t a good primary source of protein, and is probably not the best muscle builder (though it has shown benefit in elderly women on a low-protein diet and in elderly men).
Conversely, most plant proteins are incomplete, but according to the table above, the proteins in soy, pea, and rice are nearly complete: rice is relatively poor in lysine; soy and pea, in methionine. Of course, incomplete proteins can complement one another — this is true of proteins from foods as well as from supplements. The amino acid profile of a 70:30 pea:rice protein blend is similar to that of whey.
Alas, soy and pea protein powders are usually very high in salt. Salt is used in the process that makes soy and pea protein powders, and it cannot all be washed away. Check the label of your soy or pea protein powder to ensure you don’t end up exceeding your tolerable upper intake of salt (sodium) for the day: 2.3 g for most adults.
Although pea and rice are gaining in popularity, alone and in combination, soy is still the most popular vegan source of protein powder. On the PDCAAS scale, soy protein isolates score between 0.9 and 1.0, so at first glance they appear to be the virtual equals of any animal protein. However, this is because the PDCAAS scale truncates any number superior to 1. Otherwise, whey protein isolate could score a more-than-perfect 1.12.

3. Net Protein Utilization (NPU)
Like Biological Value, NPU estimates nitrogen retention but in this case by determining the difference between the body nitrogen content of animals fed no protein and those fed a test protein. This value divided by the amount of protein consumed is the NPU which is defined as the "percentage of the dietary protein retained". Miller (12) proposed a procedure which involved replicate groups of 4 weanling rats housed in group cages which were fed either the "protein-free" or the "test" diet for 10 days. These conditions were chosen empirically and the particular merits of these conditions remain to be demonstrated. Since in young animals there is a high correlation between body nitrogen and body water content (13-16), the substitution of body water measurements for body nitrogen measurements has been widely used. Indeed, measurement of body water may be more accurate than measurement of body nitrogen because sampling errors are eliminated; also, it is much more convenient and less expensive.
Since both NPU and BV are based upon estimates of "retained nitrogen", they should measure the same thing except that in the calculation of NPU the denominator is the total protein eaten whereas in the calculation of BV it is the amount absorbed. BV would be expected to be higher than NPU by the amount of nitrogen lost owing to lack of digestibility (lack of absorption). In weanling rats, it is possible that total carcass analysis is a more accurate measure of "retained nitrogen" that can be obtained from nitrogen balance measurements although this has not been proven. It is certainly less tedious. Nitrogen balance measurements must be used in large animals and in studies on man

4. Protein Efficiency Ratio (PER)
As has been indicated, qualitative differences in protein quality can be demonstrated by many methods. Protein Efficiency Ratio (PER) has been the method most widely used because of its simplicity. Osborne, Mendel and Ferry (30) observed that young rats fed certain proteins gained little weight and ate little protein whereas those which were fed better quality proteins gained more weight and consumed more protein. In an attempt to compensate for the difference in food intake, they calculated the gain in weight per gram of protein eaten and this has been called PER. It is known that the PER for any protein is dependent upon the amount of protein incorporated in the test diet. Standardized conditions have therefore been proposed (31). These include the use of 10 weanling rats per test group, diets containing 9.09% protein (N × 6.25), a test period of 4 weeks' duration, and that each experiment include a group which receives standardized casein.

The PER is calculated as the average total weight gain divided by the average grams of protein consumed. Since PER in various laboratories was not constant for the same protein, it was recommended that a corrected value be calculated using an assumed PER of the standardized casein of 2.50 (Corrected PER = 2.50 × PER/PER of reference casein).

5. Net Protein Ration (NPR)
A major criticism of the PER has been that it does not take into account the protein required for maintenance since only gain in weight is used in the calculation. Bender and Doell (36) suggested that this criticism could be avoided by the inclusion in each test of a group of animals fed a protein-free diet. Net Protein Ratio (NPR) was then calculated as the overall difference in gain (gain in weight of the test group plus loss in weight of the protein-free group) divided by the protein eaten. It is apparent that if body composition is constant, this procedure is identical to NPU except that it is expressed in arbitrary units which are less useful than the percentage of protein utilized. The weaknesses are, of course, identical with those discussed under NPU.

6. Relative Nutritive Value (RNV)
Hegsted et al. (34, 37, 38, 39) proposed a slope-ratio assay using rats in which the slope of the regression line relating body protein (or body water) of a standard protein (egg protein or lactalbumin) assumed to have maximal nutritive value was compared to that of the test protein. The tacit assumption made in the measurement of NPU or BV that these values are independent of the level of protein fed is thus tested in this procedure. As in the calculation of NPU and BV the original assumption was made that the regression line should bisect the Y axis at the point defined by the group fed the protein-free diet. As has already been discussed above, this often and perhaps, usually, does not happen. The regression lines above the maintenance level of intake are, however, linear over a substantial range of intakes with young growing rats (40) contrary to the conclusions of Miller and Payne (28). In young growing rats where maintenance requirements are relatively small compared to the growth requirements, this method is probably the most logically defensible of the assays available as an estimate of the protein quality for growth. The important question remains as to whether estimates of protein quality for growth in young rats are adequate estimates of quality for man including those of the young infant. Presumably, many proteins will be more efficiently utilized in human beings than they are for young growing rats.

7. Nitrogen Balance Index
Allison and Anderson (41) showed, as has been discussed above, that Biological Value is the slope of the regression line relating nitrogen balance and nitrogen intake and suggested that this might have certain advantages in practice over the usual method of determining BV. The concept of this index is rather similar to Relative Nutritive Value discussed above. Since it is becoming increasingly clear that nitrogen retention is not linearly related to nitrogen intake in the region of intake below maintenance, the validity of this index requires confirmation.
8. Tissue Regeneration
A variety of techniques involving the recovery of weight or of specific tissues after protein depletion have been proposed (42, 43, 44, 45). The specific merits of such assays as opposed to weight gain of young rats, for example, remain to be demonstrated.

9. Microbiological Assays
Many micro-organisms require the essential amino acids required by monogastric animals. If it were possible to find organisms which required not only the same pattern of amino acids but in the same relative amounts, their growth response when supplied with limited amounts of various proteins or protein hydrolysates would provide a simple and efficient assay of nutritive value. Considerable effort has been directed toward this (46, 47, 48, 49) and it is clear that the responses of some organisms resemble those observed with some of the rat assays described. The difficulties are clear, however, since the limitations in the animal assays mean that they provide an inadequate base for comparison with assays of this kind.

10. Plasma Amino Acids

As has been indicated in another section of this report, changes in plasma amino acid levels after the feeding of various proteins can under certain conditions yield estimates of the nutritional quality. It may be noted, however, that the range of each of the amino acids in the plasma in normal animals is relatively large. This variability imposes serious limitations upon the quantitative interpretation of any changes in the levels observed. Thus, while it may be possible to identify the limiting amino acid in certain proteins by this technique, the likelihood that good quantitative assays for nutritional quality can be developed using plasma amino acid levels is