Biochemistry

Nutrition assignment

1. WHAT DO YOU UNDERSTAND BY THE TERM ''BIOLOGICAL VALUE OF PROTEINS"

**Biological value** (**BV**) is a measure of the proportion of absorbed [protein](https://en.wikipedia.org/wiki/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](https://en.wikipedia.org/wiki/Protein_biosynthesis) in the [cells](https://en.wikipedia.org/wiki/Cell_(biology)) of the organism. Proteins are the major source of [nitrogen](https://en.wikipedia.org/wiki/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](https://en.wikipedia.org/wiki/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](https://en.wikipedia.org/wiki/Digestion) and absorbed (largely by the [small intestine](https://en.wikipedia.org/wiki/Small_intestine)). This is reflected in the experimental methods used to determine BV.

BV uses two similar scales:

1. The true percentage utilization (usually shown with a percent symbol).
2. The percentage utilization relative to a readily utilizable protein source, often [egg](https://en.wikipedia.org/wiki/Egg_(food)) (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](https://en.wikipedia.org/wiki/Mammals), and is a relevant measure in humans It is a popular guideline in [bodybuilding](https://en.wikipedia.org/wiki/Bodybuilding) in protein choice.

**Determination of BV**

For accurate determination of BV

1. the test organism must only consume the protein or mixture of proteins of interest (the test diet).
2. the test diet must contain no non-protein sources of nitrogen.
3. the test diet must be of suitable content and quantity to avoid use of the protein primarily as an energy source.

These conditions mean the tests are typically carried out over the course of over one week with strict diet control. Fasting prior to testing helps produce consistency between subjects (it removes recent diet as a variable).

There are two scales on which BV is measured; percentage utilization and relative utilization. By convention percentage BV has a percent sign (%) suffix and relative BV has no unit.

**Percentage utilization**

Biological value is determined based on this formula.

BV = ( *Nr* / *Na* ) \* 100

Where:

*Na* = nitrogen absorbed in proteins on the test diet

*Nr* = nitrogen incorporated into the body on the test diet

However direct measurement of *Nr* is essentially impossible. It will typically be measured indirectly from nitrogen excretion in [urine](https://en.wikipedia.org/wiki/Urine) [Faecal](https://en.wikipedia.org/wiki/Faeces) excretion of nitrogen must also be taken into account - this part of the ingested protein is not absorbed by the body and so not included in the calculation of BV. An estimate is used of the amount of the urinary and faecal nitrogen excretion not coming from ingested nitrogen. This may be done by substituting a protein-free diet and observing nitrogen excretion in urine or faeces, but the accuracy of this method of estimation of the amount of nitrogen excretion not coming from ingested nitrogen on a protein-containing diet has been questioned.

BV = ( ( *Ni* - *Ne(f)* - *Ne(u)* ) / (*Ni* - *Ne(f)*) ) \* 100

Where:

*Ni* = nitrogen intake in proteins on the test diet

*Ne(f)* = (nitrogen excreted in faeces whilst on the test diet) - (nitrogen excreted in faeces not from ingested nitrogen)

*Ne(u)* = (nitrogen excreted in urine whilst on the test diet) - (nitrogen excreted in urine not from ingested nitrogen)

Note:

*Nr* = *Ni* - *Ne(f)* - *Ne(u)*

*Na* = *Ni* - *Ne(f)*

This can take any value from 0 to 100, though reported BV could be out of this range if the estimates of nitrogen excretion from non-ingested sources are inaccurate, such as could happen if the endogenous secretion changes with protein intake. A BV of 100% indicates complete utilization of a dietary protein, i.e. 100% of the protein ingested and absorbed is incorporated into proteins into the body. The value of 100% is an absolute maximum, no more than 100% of the protein ingested can be utilized (in the equation above *Ne(u)* and *Ne(f)* cannot go negative, setting 100% as the maximum BV).

**Relative utilization**

Due to experimental limitations BV is often measured *relative* to an easily utilizable protein. Normally [egg](https://en.wikipedia.org/wiki/Egg_(food)) protein is assumed to be the most readily utilizable protein and given a BV of 100. For example:

Two tests of BV are carried out on the same person; one with the test protein source and one with a reference protein (egg protein).

relative BV = ( *BV(test)* / *BV(egg)* ) \* 100

Where:

*BV(test)* = percentage BV of the test diet for that individual

*BV(egg)* = percentage BV of the reference (egg) diet for that individual

This is not restricted to values of less than 100. The percentage BV of egg protein is only 93.7% which allows other proteins with true percentage BV between 93.7% and 100% to take a relative BV of over 100. For example, [whey protein](https://en.wikipedia.org/wiki/Whey_protein) takes a relative BV of 104, while its percentage BV is under 100%.

The principal advantage of measuring BV relative to another protein diet is accuracy; it helps account for some of the metabolic variability between individuals. In a simplistic sense the egg diet is testing the maximum efficiency the individual can take up protein, the BV is then provided as a percentage taking this as the maximum.

**Factors that affect BV**

The determination of BV is carefully designed to accurately measure some aspects of protein usage whilst eliminating variation from other aspects. When using the test (or considering BV values) care must be taken to ensure the variable of interest is quantified by BV. Factors which affect BV can be grouped into properties of the protein source and properties of the species or individual consuming the protein.

**Properties of the protein source**

Three major properties of a protein source affect its BV:

* Amino acid composition, and the limiting amino acid, which is usually lysine
* Preparation (cooking)
* Vitamin and mineral content

Amino acid composition is the principal effect. All proteins are made up of combinations of the 21 biological amino acids. Some of these can be synthesised or converted in the body, whereas others cannot and must be ingested in the diet. These are known as essential amino acids (EAAs), of which there are 9 in humans. The number of EAAs varies according to species (see below).

EAAs missing from the diet prevent the synthesis of proteins that require them. If a protein source is missing critical EAAs, then its biological value will be low as the missing EAAs form a bottleneck in protein synthesis. For example, if a hypothetical muscle protein requires [phenylalanine](https://en.wikipedia.org/wiki/Phenylalanine) (an essential amino acid), then this must be provided in the diet for the muscle protein to be produced. If the current protein source in the diet has no phenylalanine in it the muscle protein cannot be produced, giving a low usability and BV of the protein source.

In a related way if amino acids are missing from the protein source which are particularly slow or energy consuming to synthesise this can result in a low BV.

Methods of food preparation also affect the availability of amino acids in a food source. Some of food preparation may damage or destroy some EAAs, reducing the BV of the protein source.

Many vitamins and minerals are vital for the correct function of cells in the test organism. If critical minerals or vitamins are missing from the protein source this can result in a massively lowered BV. Many BV tests artificially add vitamins and minerals (for example in [yeast](https://en.wikipedia.org/wiki/Yeast) extract) to prevent this.

**Advantages and disadvantages**

BV provides a good measure of the usability of proteins in a diet and also plays a valuable role in detection of some metabolic diseases. BV is, however, a scientific variable determined under very strict and unnatural conditions. It is not a test designed to evaluate the usability of proteins whilst an organism is in everyday life — indeed the BV of a diet will vary greatly depending on age, weight, health, sex, recent diet, current metabolism, etc. of the organism. In addition BV of the same food varies significantly species to species. Given these limitations BV is still relevant to everyday diet to some extent. No matter the individual or their conditions a protein source with high BV, such as egg, will always be more easily used than a protein source with low BV.

2.LIST AND EXPLAIN THE VARIOUS METHODS OF ASSESSMENT OF PROTEIN QUALITY.

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).

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

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.

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.

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

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 not promising.

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.