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BCH 204

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 of protein** 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. The biological value of a protein extends beyond its amino-acid composition and digestibility, and can be influenced by additional factors in a tissue-specific manner. When a full meal is ingested, whey achieves slightly better nitrogen retention than soy or casein, which is very likely achieved by its high content of essential amino acids (especially leucine).

2.

- Methods of Estimating Protein Quality.
- Biological Value (BV)
- Net Protein Utilization (NPU)
- Amino Acid Score.
- Critique.
- Protein Efficiency Ratio (PER)
- Net Protein Ration (NPR)

<u>Biological Value (BV)</u>
It has been defined as the "percentage of absorbed nitrogen retained in the body" and a complete evaluation of the dietary protein includes measurement of the Biological Value and the Digestibility. These values are obtained by measuring the fecal and urinary nitrogen when the test protein is fed and correcting for the amounts excreted when a nitrogen-free diet is fed. True digestibility is defined as the percentage of food nitrogen absorbed from the gut
and Biological Value as

where
I = Nitrogen intake of test protein
F = Fecal nitrogen
Fo = Fecal nitrogen on nitrogen-free diet (Metabolic N)
U = Urinary nitrogen
Uo = Urinary nitrogen on nitrogen-free diet (Endogenous N)

The discrepancy here appears to be similar to that observed in NPU values for diets that provided low intakes of most of the essential amino acids.

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.

Amino Acid Score

if the composition of an "ideal protein" was known, i.e., a protein which contained every essential amino acid in sufficient amounts to meet requirements without any excess, then it should be possible to compute the nutritive value of a protein by calculating the deficit of each essential amino acid in the test protein from the amount in the "ideal protein". The "most limiting amino acid", the one in greatest deficit, would presumably determine the nutritive value.

In practice they suggested the protein in whole egg as the "ideal" since this was known to have a Biological Value closely approaching 100. They recognized that egg proteins might contain some amino acids in excess of requirements. If so, deficits of these in other proteins calculated by this procedure would be misleadingly high. That is, the calculated nutritive value would be lower than it actually was. However, Block and Mitchell compared Biological Values which were thought to have been accurately estimated and with "amino acid deficits" calculated using egg protein as the standard found a rather high correlation ($r = .86$) suggesting the overall validity of this procedure.

They also suggested that the ratio of essential amino acid nitrogen to total nitrogen (E/T) was related to, and might be a determinant of, protein quality. Since no method was proposed for combining this ratio with the Amino Acid Score, this has led to further confusion.

Critique

As has been stated, the use of estimates of protein quality to calculate the amount of protein needed to meet requirements when different diets are consumed requires that the estimate of quality vary in some known fashion, preferably in linear fashion, from zero to 100% utilization.. Rather, the regression line relating BV and Amino Acid Score indicated that proteins completely lacking an essential amino acid and which would therefore have an Amino Acid Score of zero would apparently yield a BV of approximately 25% This would mean that the requirement could be met with such proteins if they were fed at a level providing four times the estimated minimal protein requirement. This presumably cannot be true since it would imply that the protein needs could be met without a supply of all of the essential amino acids.

The regression line calculated indicates that a protein of zero score would be predicted to have a BV of 40%. If BV is to be accepted as the true measure of protein quality, then proteins of zero score should be capable of meeting protein needs if they are fed in amounts 21⁄2 times greater than that required with egg protein.

Comparison of NPU and Amino Acid Score values taken from Table 1 shows essentially the same relationship (Fig. 4) although with somewhat less deviation from expectation. According to this plot, a protein of zero score yields an NPU of approximately 25%. Thus, if NPU be accepted as the true measure of protein quality, protein needs can be met by feeding proteins of zero score at 4 times the minimal requirement.

The weakness of collecting values from a widely scattered literature in which the accuracy of neither the biological determination nor the amino acid analysis is known is, of course, recognized. However, this does not negate the clear fact that Amino Acid Score does not measure the same thing as NPU and BV.

It can be pointed out, of course, that when one is concerned with diets in which protein quality is reasonably high - NPU, BV or Amino Acid Score above 60 or 70, for example - the error in the correction will be relatively small regardless of which measure of protein quality is used. However, it is with diets of poor quality that correction is of real practical importance and for these the significance of the various measures of protein quality is in doubt.

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).

In spite of its simplicity PER has been severely criticized as a measure of protein quality (32,33,34). The most common criticisms have been that some dietary protein is required for the maintenance of the animal and this is not credited to the protein in the measurement of PER and that body composition may vary and not be an adequate measure of nitrogen retention. From the theoretical point of view the major criticisms of PER are that it is not a direct function of the nutritive value of the protein but is related to the weight gain, the amount of food consumed, the amount of protein in the diet, and the nutritive quality of the protein in the diet. The relationship between these is complex and undefined. PER also has the disadvantage that even under standardized conditions it is not reproducible in different laboratories. It is clear that PER is not proportional to the nutritive quality of the proteins tested and, for example, a protein which demonstrates a PER of 1.5 cannot necessarily be assumed to have 50% of the value of a protein showing a PER of 3.0. Thus, a statement that "the total protein (must have) ..... a Biological Value not less than 70% of casein" such as has been proposed as a standard for Textured Protein Products is not a meaningful statement. A judgment often can be made with PER whether a protein is better or worse than another protein but it is not appropriate to express these differences as percentages since the differences are not proportional to nutritional quality.

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 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.