PROTEIN EFFICIENCY RATIO OF SOME PROTEIN SOURCES USED IN POULTRY NUTRITION

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C O N T E N T S

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I N T R O D U C T I O N

Growth, reproduction, repair, maintenance, resistance to disease, and all of the faculties of the living system are correlated with the intake and utilization of foods. The foods are the raw materials which are needed to supply energy to the living machine and to construct and to repair it.

Dietary proteins, through digestion in the gastrointestinal tract, furnish amino acids, possibly polypeptides too, which are the raw materials needed to biuld the body proteins of animals. These body proteins form the matrix of the living system; they are the catalysts , the centers around which the dynamic equilibria of life develop; they are the protein stores of the body. These stores are the proteins of the gut, the liver, the plasma and other tissues of the body. There are no protein reserves in the sense that there are fat or carbohydrate reserves but the body utilizes tissue proteins to maintain the nitrogen integrity of essential structures.

The studies of Whipple and associates (1946) and

Schoenheimer and Rittenberg (1940) emphasize the dynamic equilibria which exist within these stores so that one type of tissue protein contributes to the construction of others and food nitrogen entering into these equilibria loses its identity and becomes part of body nitrogen. The primary purpose, therefore, of dietary proteins is to fill the protein stores of the body and their biological evaluation seems of great importance.

Of the main methods that have been proposed for evaluating protein quality in nutrition two have been used most extensively. The first is the biological value method which is based on nitrogen metabolism data and yields information on both digestibility and metabolic utilization.

The concept of "biological value" was first introduced by Thomas (1909) in terms of per cent of digestible nitrogen from a test food which was retained by the adult human. The original conception obviously relates to the adult nutrition and the satisfaction of the protein requirements for maintenance.

The method was first applied to the growing rat by Mitchell (1924 a) to include the value of dietary protein in covering the requirements for maintenance and growth. The biological value assumes a different meaning in such

experiments; it measures the percentage of absorbed nitrogen retained for growth and for the replenishment of endogenous losses. The technique carrying out the test has been improved from time to time (Mitchell and Carmen, 1926; Mitchell, Hamilton et al 1945), and the validity of underlying assumptions have been tested experimentally (Mitchell, Burroughs et al. 1936), and particularly with reference to the immensely important contribution of Schoenheimer and his associates (1942) to our knowledge of protein metabolism (Mitchell 1943; 1944).

The method has been criticized, mainly on the grounds that Schoenheimer's work has destroyed completely the distinction that Folin (1905) proposed between endogenous and exogenous metabolism of protein or rather nitrogen. However, the reality of a relatively constant minimum endogenous catabolism of nitrogen, commensurate with the protein requirement for maintenance, is not impaired the slightest by Schoenheimer's investigations; Schoenheimer's own conclusion to the contrary not with standing.

The other method of measuring the nutritive value of protein is that proposed and developed by Obsorne , Mendel and Ferry (1919; 1920), and involves the

determination with growing rats the maximum ratio of body weight gains to protein consumed for each test protein, and is defined as the Protein Efficiency Ratio.

This method, as commonly used, has received critical attention (Mitchell 1924, 1938, 1943 and 1944 ; Block and Mitchell 1946; Hegsted and Worcister, 1947), first because in the hands of many investigators, no systematic attempt was made to find the dietary level of a given protein that would yield maximum efficiency, and, second, because the method has not been generally standardized.

Since this method of protein evaluation is relatively simple and is probably the best method in current use in which protein quality is assayed in terms of growth measurements, and since separate collection of excreta is not required in the technique of the method it was decided, therefore, to apply such method in biological evaluation of protein used in poultry nutrition.

REVIEW OF LITERATURE

Protein Efficiency Ratio Method of Biological Evaluation of Proteins :

The determination of the diverse nutritive values of individual proteins and protein mixtures was a new problem some sixty years ago. It was attacked at that time by new feeding methods involving the preparation of synthetic rations in which in particular the protein content is under control. The pioneer work of this character was done with isolated proteins by Osborne and Mendel. Their studies of the value for growth of casein, lactalbumin and the many vegetable proteins isolated and identified by Obsorne from a wide variety of seeds are of great historical significance.

At first they were concerned merely in finding out whether or not each of these proteins is complete in the sense that it is able to support growth in young rats. Uncontrolled feeding served the purpose well, but when they wished to assess quantitatively the diverse nutritive values of protein they early recognized the necessity of the rigid control of food intake. In their most exact

comparative animals and varied the concentration of the protein under test until equal gains were secured. The relative nutritive values of the proteins were then inversely proportional to the concentrations of protein to produce equal rates of growth.

However, the maintenance of the energy intake of growing animals at a constant level and the adjustment of the various protein intakes so that the rates of growth of experimental animals are identical is difficult and laborious. In an attempt to obviate some of these difficulties without sacrificing too much in accuracy, a method whereby the nutritive values of proteins may be expressed numerically by relating the gain secured to the intake of protein was deviced by Osborne, Mendel and Ferry (1919) and was defined as the "Protein Efficiency Ratio".

The method as originally proposed involved the testing of rations containing progressively increasing percentages of the test protein in order to find the level that would yield maximum efficiency but as followed in practice some arbitrary level of protein, generally 10% is used The experimental animals are fed ad-libitum and the protein values are expressed in grams of gain

secured per gram of protein consumed during a feeding period, of arbitrarily determined duration.

Contrary to the hopes of its sponsores the method is not a satisfactory substitute for the more elaborate method it superseded. Nevertheless, it has been widely used in nutrition laboratories. The method as commonly used, has been criticized by Mitchell and, indeed, some of its shortcomings were realized by its originators.

Barnes and his associates (1945 & 1946), working with mice, made a careful study upon the protein efficiency method which led Bosshardt et al. (1946; cit. Frost 1959) to a new improved technique in which maximum efficiency ratio could be reached.

They concluded that "the common practice of applying a 10 percent protein diet, regardless of the nature of the protein, will result in a considerable distortion of nutritive values, and the magnitude of the error will increase as the nutritive quality of the protein decreases"

Paired feeding is often used in place of ad-libitum feeding to equalize the ingestion of the test proteins under comparative assay. These authors have pointed out, however, that if the restriction is severe in paired

feeding some of the better protein may be wasted as fuel.

Again, Block and Mitchell (1946) have criticized the refinement in the method made by Bosshardt as being too combersome to be generally followed.

Harte et al. (1947) have made comparison of moderate restriction of food intake vs ad libitum feeding in the determination of protein efficiencies in rats. Somewhat partial restriction of food intake (10 g. of casein ration daily) reduced the growth response on 10% casein by approximately 20% below the mean for ad libitum feeding. The variance, however, for the animals restricted in quantity of diet was only about one-eighth to one-tenth that observed for animals fed ad-libitum.Thus, food restriction improved the discriminatory capacity of a protein efficiency assay on rats. These authors emphasized, however, the need to study further the physiological implication of partially restricting the food intake.

Hegsted and Worcester (1947) found a very high correlation between gain in weight and protein efficiency measurements in rats. They found, too, that protein efficiency is a function of weight gain rather than a

characteristic of the dietary protein, and concluded that little additional information is gained in these growth methods by calculating protein efficiencies.

In some studies on the utilization of proteins of white and whole-wheat flour, Chick, Copping, and Slack (1946) found that protein efficiency ratios reflected the retention of nitrogen in the body of animals as determined by carcass analysis. Both good and poor correlation between growth and nitrogen retained are obtained, therefore, depending upon the nature of the growth of the animal.

Mitchell (1943, 1944) has discussed thoroughly the shortcomings of the protein efficiency method for comparative assay of dietary proteins. He emphasized that the method assumes : (1) that there is no requirement for maintenance and (2) that the protein content of the gains in body weight of growing animals is constant.

Similarly, Albanese (1947), in a review of the amino acid requirements of man, pointed out"that composition of weight gain differs in quality, sometimes it may predominate in fluids and other times in fat or protoplasmic tissues. This discrepancy also raises questions