The Protein Requirements of Sheep

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J Anim Sci 1932. 1932:37-41.

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Owing to the confusion of the two concepts, the protein requirements and the protein of feeding standards, statements of their relationships and differences are given.

The protein requirements of sheep or other animals are such amounts of protein as are needed to fulfill the specific purposes for which the protein is fed with no surplus and no deficit in any particular, other requirements being met by an adequate intake of all other nutrients. This view of the protein requirements naturally leads to the amino acid requirements, but the impractical nature of this phase of the problem in the present state of our knowledge essentially eliminates it from consideration. In lieu of the amino acid requirements must be substituted the requirements of a protein, a mixture of proteins, or proteins supplemented by amino acids which approach as nearly as possible 100 per cent utilization for the purposes specific for protein.

The amount of protein recommended in feeding standards is such quantity as is needed to meet the protein requirements and, in addition, an amount that will provide for the variations in the composition and digestibility of given feeds, for the variations in the degree of utilization of proteins in different combinations and from different sources, for individual variation in animals, in some cases, for group feeding with consequent variations in intake of feed, and, in some measure, for the economic factors involved.

In the one instance reference is made to a specific quantity capable of determination with a high degree of accuracy. In the other instance the quantity is dependent on a number of factors, some of which are variable within themselves as well as in their interrelations. In the past the tendency has been to attempt to provide specific information on both requirements and standards in one type of experiment, a procedure which is obviously illogical. The attempt to measure the sum of several factors may yield preliminary results that will be helpful in the absence of more accurate information, but these results will not possess specific character owing to the variable and uncontrolled nature of some of the factors in the

* Presented as a part of a Symposium on the Protein Requirements of Farm Animals and the Evaluation of Feeds as Sources of Protein.

usual experiment relating to the amount of protein to be recommended in feeding standards. A study of each of these factors separately will prove productive of more accurate results.

Protein Requirements

As indicated by the title this paper is limited to a consideration of the protein requirements of sheep and is not concerned with feeding standards except insofar as the requirements provide the basic information on which the standards are based.

A few attempts to determine the protein requirements for maintenance of sheep, notably those of Schulze and Maercker and of Katayama, have been attended with a reasonable degree of success. The former fed digestible crude protein on as low a level as 0.335 pound per 1000 pounds live weight on which nitrogen equilibrium was attained. The wethers fed by Katayama attained nitrogen equilibrium on 0.375 and 0.432 pound of digestible true protein per 1000 pounds live weight daily. These quantities of protein did not provide for the probable growth of wool during the period of the test.

As a further indication of the maintenance requirements of sheep the endogenous nitrogen eliminated in the urine on an adequate energy intake was determined on mature wethers as subjects by Scheunert, Beger and Westhausser and on growing wether lambs by Voeltz and by Scheunert, Beger and Westhausser. Apparently these determinations were the most successful of those studied. The endogenous protein (urinary nitrogen x 6.25) ranged from 0.149 to 0.194 with a mean of 0.176 pound per 1000 pounds live weight daily. On the basis of these results the requirement of proteins having a biological value of 50 per cent would be practically the same as that obtained by Schulze and Maercker noted above. The requirement of proteins having a biological value of 75 per cent calculated in the same manner would be 0.235 pound per 1000 pounds live weight daily. In view of these results we feel justified in the statement that the protein required for the maintenance of sheep could scarcely be over 0.35 pound per 1000 pounds live weight daily, with no provision for the growth of wool.

The chapter on the protein requirements for the growth or

the growth and fattening of sheep is wholly unwritten as far as published results indicate. The results that are listed under that head contribute to the formulation of feeding standards, but they have little application in the determination of the protein requirements. Much the same situation obtains relative to the protein requirements of lactation and pregnancy.

It is of special interest that Dr. Mitchell and his associates at the University of Illinois have done some work on the additions of protein during growth by Shropshire rams and ewes. Through their courtesy unpublished results on the amounts and rates of addition of protein are available. Shropshire rams added 20.2 pounds of protein in advancing in age from 1 to 388 days and in weight from 8.5 to 139 pounds. Similarly, Shropshire ewes added 18.2 pounds of protein in advancing in age from 1 to 407 days and in weight from 8.0 to 120 pounds. The respective daily rates of addition of protein were 0.0524 and 0.0448 pound per head daily. These results include the protein of the wool which made up 25 to 38 per cent of the total protein of the year-old sheep.

The quantitative determination of the proteins secreted in the milk during a lactation period is not a particularly difficult undertaking, and results of this character would constitute a further valuable contribution to our knowledge of the protein requirements of sheep.

Numerous determinations of the protein requirements for the growth of wool by mature sheep have been made, mainly by German investigators. The results vary from 0.10 to 0.17 pound per 1000 pounds live weight daily with a mean of 0.13 to 0.14 pound. In this connection it should be noted that these requirements may be rather high for most breeds of sheep grown in this country as the animals used in these investigations were often coarse wool sheep that appeared to be small in size in proportion to the amount of wool produced.

New And More Refined Methods Needed

Let us now consider the steps that should be taken to complete the cycle of information on the protein requirements of sheep. The methods used in the attempts to determine the protein requirements for growth, for example, are not well adapted to such studies. The proteins used have been too

largely unknown quantities, the control has been too limited, and the provision of the other factors in the ration has been done in an unsystematic manner. Feeding has been done mainly by trial and error without the guides of nitrogen balances. Sufficient consideration has not been given to the variations in composition and digestibility of given feeds from different sources. It seems that with the plans used thus far the task of determining the protein requirements for growth is an almost infinite one.

Two alternative plans seem to be available. First, the use in feeding experiments of rations that are synthetic, in part at least, the proteins of which are highly digestible and of high biological value. These rations should contain adequate amounts of the other nutritive factors as they are known at present. The feeding should be done under strictly controlled conditions with determinations of nitrogen balances at frequent intervals or continuously throughout the test period. If the proteins in use undergo rapid digestion and absorption it may be necessary to adjust the intervals between feedings to prevent amino acidemia with consequent deaminization of amino acids that would otherwise be utilized for the synthesis of proteins rather than for direct or indirect production of energy.

Second, the use of the methods proposed by Dr. H. H. Mitchell in Bulletins 55 and 67 of the National Research Council and more recently in the monograph of Mitchell and Hamilton on the "Biochemistry of the Amino Acids."

It is to be hoped that both methods will be used in future investigations of these problems. There is reason to believe that they represent different ways of obtaining the same result with the possible introduction of certain compensating factors. If combined requirements, such as maintenance and growth or maintenance and milk production, are under consideration, each requirement as well as each factor influencing it should be measured separately and the sum of these known results measured as a final check. It is only by these or similar methods that discussions of protein requirements and of the quantities of protein recommended in feeding standards will advance from the more or less speculative to the exact phase.

It is interesting to recall that the protein requirements for

the growth of wool are based wholly on the protein content of the wool produced and the protein requirements for milk production on the amount and composition of the milk, but there seems to be some hesitancy about the acceptance of the same principle when applied to the growth of body substance. The classic work of Prof. Haecker on the protein requirements for milk production marks the beginning of the present day methods of formulating standards for milk production, the chief significant modification in his proposed standards being in the amount of load added to the actual requirements as a safety factor. As far as available information indicates the same basic principles apply whether the protein represents an addition to a product that is carried internally or to one that sooner or later appears externally.

BASAL METABOLISM AND HEAT INCREMENTS IN GROWING FARM ANIMALS[1]

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The energy cost of maintenance of an animal is the sum of its basal energy metabolism (energy cost of maintenance during non-productive rest while in post-absorptive condition) and the energy increments expended for the several superimposed processes such as "intestinal work," standing, walking, gestating, lactating, growing, fattening, etc. An analytic investigation of the problem of energy needs must necessarily involve an investigation first, of energy needs for "basal" metabolism, and second, energy needs for the various extra activities. Such an investigation is at present under way at the Missouri Experiment Station, and this is a preliminary report on it.

Method

The data were obtained by a method not previously used in investigating farm animals. It consists (Fig. 1) in connecting the respiratory system of the animal to a counterpoised bell filled with oxygen, with the bell freely moving in a water trough which acts as a seal for the enclosed oxygen. As the

1. This is paper No. 30 in the Herman Frasch Foundation Series.