NITROGEN BALANCE WITH SHEEP ON RATIONS CONTAINING UREA[1]

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Confirmatory evidence of the utilization of urea nitrogen by ruminants has been obtained in recent group-feeding tests with steers and nitrogen-balance experiments with both steers and sheep (Briggs *et al.* 1947). According to present concepts this utilization is made possible through the intervention of rumen organisms which convert urea nitrogen to protein nitrogen which in turn is digested and absorbed by the host. It has been suggested that the first step in this conversion is the hydrolysis of urea to ammonia (Pearson and Smith 1943). In fact, recent experiments have demonstrated the rapid formation of ammonia and its absorption via the portal system following the administration of urea to sheep (Dinning *et al.*, MS.). Likewise, experiments with steers have demonstrated a rise in both urea-N and ammonia-N of systemic blood following urea administration (Dinning *et al.*, MS.). It is evident, therefore, that ammonia formation is one of the predominating reactions taking place in the rumen of animals fed urea. Consideration of the possibility that ammonia formed in the rumen contributes to the positive nitrogen balance of sheep fed urea brings to mind the early work of Taylor and Ringer (1913) who fed ammonia salts to dogs, and the more recent studies of Schoenheimer (1946:25-46) who fed isotopic nitrogen compounds to rats. The former workers were able to recover from the excreta of dogs only about 50 percent of the nitrogen fed as ammonium salts of organic acids. Schoenheimer fed ammonium citrate which contained isotopic nitrogen to rats and recovered appreciable quantities of the isotope in amino acids isolated from tissue proteins. The results of these isotope studies, according to Schoenheimer, do not imply protein synthesis but demonstrate merely the replacement of protein nitrogen by the nitrogen from ingested ammonia. It seems a logical suggestion that this replacement occurs during the deamination and resynthesis of amino acids making up the protein, the latter reactions taking place under conditions of both adequate and inadequate protein intake.

Although there appears to be no completely satisfactory explanation of the favorable effect of ammonium salts on the nitrogen balance of animals with simple stomachs, suppression of deamination of animo acids has been suggested. As applied to ruminant nutrition, the explanation that protein is synthesized from ammonia in the rumen and digested in the lower regions of the gastrointestinal tract is possibly inadequate. In the general acceptance of this theory, due regard has not been given to the observation that during periods of positive nitrogen balance effected by urea ingestion, fecal-nitrogen values sometimes increase and at other times remain unchanged or even decrease. Whenever fecal nitrogen is unchanged, it is to be assumed that the bacterial protein synthesized is completely digested and that its digestion causes no increase in the metabolic-nitrogen fraction of the feces. A decrease in fecal nitrogen would indicate that the presence of urea enhances the digestibility of other nitrogenous constituents of the basal ration. Probably very little, if any, protein is synthesized when low carbohydrate rations are fed.

In a recent series of balance trials with lambs, addition of urea to the basal rations failed to produce a measurable increase in the excretion of fecal nitrogen although it produced a marked increase in the positive nitrogen balance. Possible loss of nitrogen in the collection and analysis of feces was then investigated.

Feces samples taken directly from the colon of the lambs at different intervals after feeding contained an average of 0.52 mg of urea-and-ammonia

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nitrogen per gram (dry-matter basis). Differences between samples taken at the same time interval were unrelated to differences in urea intake. When the feces were spread on screens and allowed to air-dry over night they lost from 40 percent to 50 percent of their urea-and-ammonia nitrogen.

Feces collected at 12-hour intervals from screens directly beneath the lambs in metabolism cages were, in most instances, higher in urea-and-ammonia nitrogen than those taken from the colon. These values on a dry-matter basis averaged 0.70 mg per gram for lambs on the basal ration and 1.66 mg per gram for those receiving additional nitrogen as urea. Apparently small amounts of urea and ammonia normally present in feces are lost by urease activity and volatilization of ammonia during collection periods; however, when feces are collected on screens, as described, they gain in these constituents, presumably as a result of urine contamination.

Losses of nitrogen when the feces were oven-dried at 105° C were found to vary according to the amounts of urea and ammonia present. These losses from feces containing over 1.0 mg of urea-and-ammonia nitrogen per gram of dry matter comprised from 4 to 11 percent of their total nitrogen. Losses from drying feces containing smaller amounts of these forms of nitrogen were not detected in usual Kjeldahl procedures.

Although the errors involved in feces collections are not of sufficient magnitude to account for the greater positive nitrogen balance of the lambs on the urea rations, they may account for the small differences observed in fecal-nitrogen values. Likewise, values for urinary nitrogen may be higher than actually found since the quantitative collection of urine containing labile forms of nitrogen is subject to even greater error and requires vigilant care.

From a consideration of published data it appears that ingested urea, apart from its role of furnishing nitrogen for rumen bacteria, has other favorable effects on nitrogen retention by ruminants. Among these effects may be suppression in the liver of deamination of amino acids from food and body protein through the action of ammonia produced in the rumen. Suppression of these reactions, which would spare indispensible groupings, and synthesis of nonessential amino acids, should promote the synthesis of body protein.

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