QUALITATIVE AND QUANTITATIVE ASPECTS OF AMINO ACID DIGESTION IN SHEEP

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ABSTRACT

A conventional digestion trial was conducted with three sheep fed three rations in a latin square design. Twenty-day digestion periods were divided in two to check for repeatibility of results. A sampling regime designed to measure volume of duodenal flow and obtain representative samples for chemical analysis was superimposed on the digestion trial. The rations had equal protein levels, but varied in amino acid and digestible energy content. Ration components were ground corn and legume-brome hay mixed in different proportions to give three different levels of digestible energy.

The highest energy ration gave significantly higher coefficients of digestibility of ether extract, nitrogen free extract, and gross energy than the other rations. Digestion of crude fibre was significantly highest on the high roughage ration, while ash and protein digestibilities were ration independent.

Hourly flow estimates were averaged within four equally spaced divisions of the day, and significant differences among these divisions was taken as evidence of diurnal variation in rate of fore-stomach emptying. The diurnal variation was monophasic, corresponding to feeding the rations once a day. Although data obtained on flow within periods appeared acceptable there was a significant variation in ten-day total flows among periods. Composite duodenal

samples made on an aliquot basis from within period flow data were used to estimate average composition of duodenal contents on the three rations.

Changes in percentage composition from feed to duodenal level showed protein and ash to give large increases, with ether extract and gross energy remaining fairly constant, and nitrogen free extracts declining. Wide ration differences in amino acid levels failed to cause significant ration effects on composition of duodenal protein. The evidence indicates that rumen fermentation removed ration differences in amino acid levels. The high energy ration resulted in a higher percentage of soluble carbohydrate in the duodenal digesta than the other two rations.

Estimates of dry matter passage through the duodenum based on assumptions on the amount and location of fibre digestion showed the high fibre rations to have significantly larger dry matter passage than the high corn ration. Calculations based on dry matter passage showed a net addition of crude protein and ash by the fore-stomach for all rations. Gross energy, nitrogen free extracts, and ether extract were more highly digestible in the rumen on the rations containing the most corn. Amounts of soluble carbohydrate entering the small intestine varied from an average of 62 gm per day on the high roughage ration to 109 gm per day on the high corn ration.

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INTRODUCTION

Digestion in the ruminant is characterized by fermentation followed by enzymatic digestion and then finally fermentation. Products of rumino-reticulum fermentation include gases which may be absorbed or lost by eructation, and other materials which may be absorbed from the rumen or passed on to the lower gut. The residual material leaving the fore-stomach contains partially degraded ration components and microbial material. After enzymic digestion in the small intestine the remaining constituents are subjected to fermentative attack by microorganisms of the large intestine. By partitioning digestion into fore-stomach and intestinal effects one can determine the contribution of each region to nutrient synthesis and absorption.

Importance of this partitioning can be demonstrated by considering the differences in nutrient utilization associated with the two areas. Fermentation of protein in the rumen gives partial hydrolysis of protein to amino acids which in turn may be deaminated. Ammonia from this source when present in excess is absorbed into the portal blood stream and converted to urea in the liver. Ammonia in the rumen may be synthesized into microbial protein. Both the quantity and quality of protein leaving the rumino-reticulum can differ from that in the ration. An independent method

for measuring the absolute amount of protein leaving the fore-stomach and its amino acid content are required before quantitative information can be obtained about intestinal digestion and absorption of protein in the ruminant. There is almost nothing known about the effect of ration protein on amino acid composition of digesta entering the duodenum.

Fermentative microorganisms in the rumen attack starches and more complex carbohydrates, giving volatile fatty acids, methane, and carbon dioxide as the main breakdown products. Short chain fatty acids are absorbed by the rumen epithelium and passed into the portal blood system. This fatty acid absorption accounts for a large proportion of energy absorbed from the ration. Intestinal hydrolysis of soluble carbohydrate to monosaccharides provide another potential source of energy for the ruminant. It is generally considered that with high roughage rations the amount of soluble carbohydrate escaping fermentation in the rumen is negligible. However rations containing high levels of digestible energy can pass through the rumen rapidly enough to escape complete starch degradation. Since the heat loss from fermentation accounts for an appreciable amount of ration energy, any factors which can increase the amount of monosaccharides absorbed from the small intestine will show increased efficiency of energy utilization. Since little information is available concerning the amount of soluble carbohydrate entering the duodenum, a measurement of this

would be helpful in the partitioning of carbohydrate digestion between the fore-stomach and lower digestive tract.

The present experiment was designed to estimate the effects of different rations on digestion occurring before and after the fore-stomach with special emphasis on amino acids. In addition the amount of crude fibre, ether extract, energy crude protein, nitrogen free extract, and soluble carbohydrate digestion occurring in the rumen was studied.

In order to conduct a study of this type one has to quantitatively measure the flow of digesta into the duodenum. This was done using fistulated sheep and a marker dilution technique which has been described by Phillips and Dyck (1964).

LITERATURE REVIEW

FLOW MEASUREMENT

In discussing the difficulties associated with attempts to measure the volume of digesta entering the lower alimentary tract of ruminants, Singleton (1961) stated that, "an ideal method of measurement would be applicable to the animal without producing any disturbance in its normal behaviour, so that recordings could be made over several successive days without the animal being moved from its usual location". Methods described to date have usually fallen far short of this ideal.

The anatomical locations at which flow measurements have been made are the omasal-abomasal junction, the region of the pylorus, and the first few inches of the duodenum. Oyaert and Bouckaert (1961) cannulated the omasal-abomasal orifice of sheep in a method which allowed them to block the orifice and collect all the material which would normally flow into the abomasum. A solution of polyethylene glycol was introduced into the rumen and the recovery at the omasal-abomasal level provided an estimate of flow independent of the volume collected. Failure to return the collected material to the abomasum gave an increase in water consumption in the experimental animals, and the dry matter content of the digesta was found to

decrease with time on collection. These observations, combined with greater than 100% marker recovery, indicated that the collection technique was increasing flow above normal levels. Total collection values were corrected for 100% marker recovery to give an average hourly omasal outflow of 462 ml with a feed intake of one kg of dry matter.

This method of flow estimation has been more extensively used in the region of the pylorus and the first part of the duodenum. This region is more accessible for experimental surgery than is the omasal-abomasal orifice.

Flow data obtained at the duodenal level does not give an accurate estimate of the fore-stomach effect due to the volume of secretions added by the abomasum. However little or no absorption occurs from the abomasum so quantities of nutrients estimated at the duodenum will be very similar to the quantities passing through the omasal-abomasal orifice. Therefore duodenal flow values showed the amounts of materials entering the small intestine, and thus available for digestion and absorption.

Phillipson (1952) studied duodenal flow using two distinct experimental preparations. One method involved exteriorization of flow between a cannula in the pyloric part of the abomasum and another in the duodenum, but the sheep did not survive. The second preparation consisted of