DIGESTION OF PROTEIN. IN THE INTESTINES OF THE SHEEP

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Summary

Studies have been made of the digestion of nitrogen (N) and of organic matter (OM) in sheep offered thirteen gramineous roughages of widely differing nutritive value. It was concluded that the true digestibility of crude protein in the intestines ranged from 74 to 82% (mean 78%). These estimates were based on observations that, while metabolic faecal N (MFN) was equal to 0.4 g/100 g OM intake, less than one third of the MFN came from endogenous secretion into the intestines. The intestinal component of MFN was equal to 0.18 g/100 g OM leaving the stomach. The possible use of this information in studying protein digestion in grazing sheep is discussed.

I. INTRODUCTION

In recent years, substantial progress has been made in the study of quantitative aspects of protein digestion by the ruminant. It is well recognized that the apparent digestibility of proteins is lower than the true digestibility because of the excretion of metabolic faecal nitrogen (MFN) (Hutchinson 195 8; Blaxter 1964). However, corrections for MFN do not necessarily indicate the main nutritional aspect of protein digestion, namely the amounts of amino acids absorbed from the digestive tract, because substantial amounts of dietary N may leave the digestive tract of the ruminant in the form of ammonia (McDonald 1952). Furthermore, it is now recognized that, on low protein diets, a substantial gain of "crude protein" may occur in the digestive tract as a result of protein synthesis by rumen micro-organisms from N recycled into the rumen (Clarke, Ellinger and Phillipson 1966; Hogan and Weston 1967b).

In recent studies of the digestion of chopped roughages fed to sheep at levels approaching *ad libitum* (Weston and Hogan 1967; Hogan and Weston 1967a), observations have been made of the net effect of digestion in the whole stomach on the amounts of crude protein and organic matter (OM) that pass in the digesta to the small intestine. In the present communication, estimates are presented of the MFN derived from secretions into the intestines and of the apparent. and true digestibility of protein in the intestines. These estimates are preliminary, pending the analysis of further data, but they are presented here to indicate some factors influencing protein digestion in the sheep.

II. MATERIALS AND METHODS

The measurements were made on Merino wethers fitted with permanent rumen and abomasal fistulae. The diets, offered at levels approaching the *ad*

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libitum intake, consisted of wheaten hay (*Triticum vulgare*), H1 rye grass (*Lolium perenne* x *Lolium multiflorum*) harvested at five stages of maturity, and seven diets of forage oats (*Avena sativa* var Cooba) grown with and without the application of calcium ammonium nitrate and harvested at different stages of maturity. Apart from the wheaten hay and one rye grass sample which were sun-cured, the forages were dried in a grass drier using a forced draught of air but with little heat. The diets contained a wide range of values for cell wall constituents (50-69% on an OM basis), crude protein (6-32%) and soluble carbohydrate (5-18%). The digestibility of OM ranged between 53 and 82%, and the apparent digestibility of N between 43 and 89 %.

The rates of flow of N and OM were measured by reference to the markers lignin and ^{51}chromium complexed with ethylenediamine tetraacetic acid. The experimental and analytical techniques were described more fully in earlier papers (Weston and Hogan 1967; Hogan and Weston 1967a). Crude protein passing from the stomach was estimated as N other than ammonia (NAN) x 6.25. Metabolic faecal N (MFN) was estimated by adapting the technique used by Blaxter and Mitchell (1948). MFN derived from the whole alimentary tract was calculated from the regression of g faecal N/ 100 g OM intake on g N/ 100 g OM in the diet. MFN arising through secretion of endogenous N into the intestines was calculated from the regression of g faecal N/ 100 g OM passing from the stomach on g NAN/ 100 g OM passing from the stomach. The regression g/day faecal N on g/day NAN passing from the stomach was also estimated. The regression equations were calculated using the methods employed by Lamboume and Reardon (1963).

III. RESULTS

(a) NAN leaving the stomach

More NAN passed from the stomach to the intestines than was ingested with diets in which N represented less than 4% of digestible OM (Figure 1). Even with those diets containing higher proportions of N, the losses from the stomach (uncorrected for secretions into the abomasum) were less than 20% of dietary N.

(b) Estimated true digestion in intestines

The influence on faecal N of the quantity of OM passing from the stomach (Figure 2) follows a general relationship $y = 0.18 + 0.22x$, where $y =$ g faecal

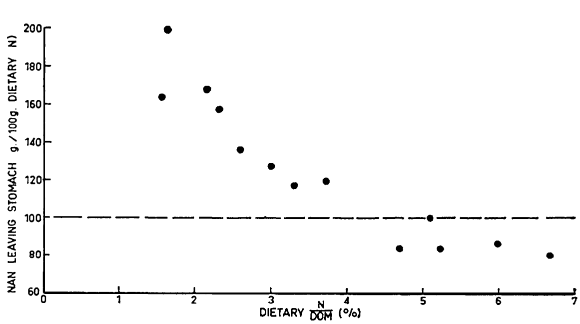

Fig. 1.—The effect of dietary composition (nitrogen, N, as a proportion of digestible organic matter, DOM) on the quantity of N in forms other than ammonia (NAN) leaving the stomach.

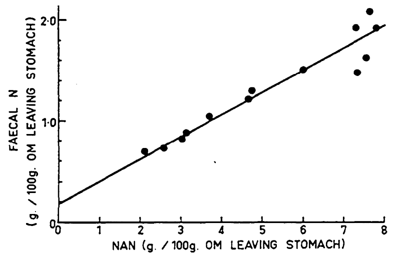

Fig. 2.—The relationship between N excretion in faeces per unit of OM leaving the stomach and the concentration of N in forms other than ammonia (NAN) leaving the stomach.

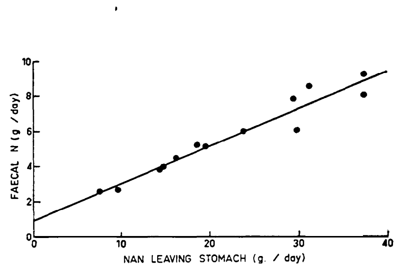

Fig. 4.—The relationship between the quantity of N excreted per day in the faeces and the quantity of N in forms other than ammonia (NAN) leaving the stomach per day.

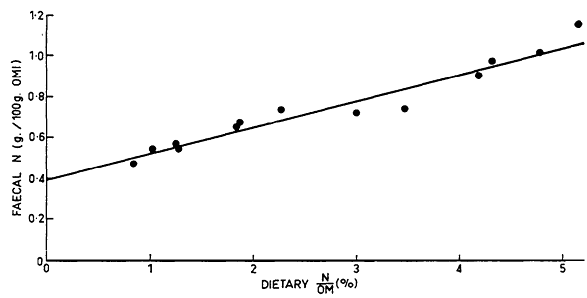

Fig. 3.—The relationship between N excretion in the faeces per unit of OM intake and the concentration of N in the diet.

N/100 g OM leaving the stomach and x is the concentration of NAN in the OM leaving the stomach. Assuming the validity of extrapolating from the present data to the situation where the digesta were N-free, the MFN would be 0.18 (S.E. ±.03) g/100 g OM leaving the stomach. The regression coefficient here represents indigestibility of N leaving the stomach, and hence the mean true digestibility was 78 %. When the estimated value for MFN was applied to the diets studied, true digestibility ranged from 74 to 82%.

The influence on faecal N of OM intake (Figure 3) follows a general relationship a = 0.4 + 0.13 b, where a = g faecal N/ 100 g OM intake, and b is the concentration of N in the dietary OM. From the extrapolation of these data it appears that for a N-free diet, approximately 0.4 g N were excreted in the faeces/ 100 g OM intake. The value for this measure, classically referred to as MFN, with a mean OM intake of 734 g/day, was thus approximately 2.9 g/day. By contrast the MFN derived from the intestines, calculated on the basis of 420 g OM/day passing from the stomach, was approximately 0.76 g/day or one quarter of the total MFN.

Faecal N was reasonably well correlated with NAN leaving the stomach (Figure 4). The intercept 0.77 gN (S.E. ± 0.12) represents MFN derived from secretions into the intestines. This value for MFN would be expected from the equation in Figure 2 because in the present experiments 360-495 (mean 420) g OM/day passed from the stomach.

IV. DISCUSSION

It has been suggested that the obligatory wastage of faecal N by the ruminant has serious nutritional consequences to the animal consuming low protein diets (Hutchinson 1958; Blaxter 1964). Blaxter indicated that protein synthesis in the rumen strongly influenced the high level of excretion of MFN which, in the ruminant, was more than 0.4 g/100 g dry matter intake compared with 0.1-0.2 g/100 g dry matter intake in non-ruminant animals. However, no quantitative data have been presented to separate MFN arising in the stomach of the ruminant from that arising in the intestine. Estimates of MFN in the present data, 0.4 g/100 g OM intake, are similar to those summarized by Blaxter. It appears that less than one third of this MFN arises in the intestines; hence the endogenous secretions into the intestines affect MFN in the sheep to much the same extent as in non-ruminants.

The remaining two-thirds of the MFN appeared to arise in the stomach. It is unlikely that endogenous secretions in saliva and into the abomasum contribute significantly to MFN; hence it is probable that the MFN arising in the stomach consists mainly of undigested microbial protein; this protein would be synthesized by rumen micro-organisms from N supplied in part from the diet and in part from endogenous sources. Two points about this fraction of the MFN are worthy of comment: (i) the validity of using MFN to estimate true digestibility of a dietary protein is clearly open to doubt, (ii) with most of the present diets, a substantial gain of N occurred as the digesta passed through the stomach. If the undigested residue of this recycled N was measured as MFN, the high excretion of MFN, far from being an expensive drain on the protein economy of these ruminants, would be a relatively small price to pay for the benefits of N recycling in the stomach.

The true digestion of N in the intestines did not differ appreciably over a wide range of diets. The mean digestibility, 78%, was low, but this might be expected from published data on the true digestibility of rumen bacteria (Hungate 1966). It was probably not due to the capacity of the intestines to digest protein because casein infused into the abomasum is almost completely digested (Reis and Schinckel 1961; Blaxter and Martin 1962).

The close relationship between faecal N and NAN leaving the stomach suggests a way to predict with grazing sheep both the quantity of N leaving the stomach and the quantity of N digested in the intestines.

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