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Improving the efficiency of utilisation of pasture protein by sheep

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ABSTRACT

The utilisation of a supplementary energy supply and its effects on urea metabolism and rumen function were examined in sheep fed indoors on fresh lucerne (*Medicago sativa* cv. Rere) (N content, 34 g/kg DM). Sheep were fed hourly and infused intraruminally with either water (1200 ml/d; n = 5; N intake, 33.0 g/d) or a similar volume containing sucrose (160 g/d; n = 4; N intake, 32.1 g/d).

The additional energy resulted in a lower rumen fluid ammonia concentration (264 v 142 mg N/l), lower plasma urea concentration (258 v 172 mg N/l), less urinary urea was excreted (18.9 v 13.0 g N/d), more urea was recycled to and degraded in the gut (7.6 v 13.0 g N/d) and N balance (measured in 2 animals on each treatment) was improved (+ 1.4 v + 5.5 g N/d). All of the sucrose was fermented in the rumen and was accompanied by an increase in the concentration of rumen fluid propionic acid (28 v 40 mM/l, and decreased acetic acid (49 v 39 mM/l). In a comparable experiment with sheep fed chopped lucerne hay, continuous infusion of sucrose also resulted in increased propionic acid levels in the rumen which was reflected in an increase in plasma glucose production (113 v 188 g/d) in the infused group.

The results suggest that supplementary fermentable carbohydrate is effective in improving the efficiency of utilisation of pasture protein. The effect appears to be 2-fold: excess ammonia-N is captured as microbial protein which is then available for enzymic digestion in the lower gut; the additional fermentative activity increases propionate production which in turn is available for glucose production, thus *sparing* amino acids for tissue protein utilisation.

Keywords Sucrose; urea metabolism; sheep.

INTRODUCTION

Pasture grasses and legumes are of maximum nutritive value when growing rapidly and in the vegetative state as in the spring. However, a high proportion of fresh herbage protein is readily digested by micro-organisms in the rumen and when pasture protein content is high (above 30 g N/kg DM) excess ammonia-N is produced, absorbed and excreted as urinary urea-N.

Pasture protein can be utilised more efficiently if protected against ruminal degradation, such as occurs with tannins. It is also theoretically possible to improve rumen microbial protein yield through capture of excess ammonia-N by supplying additional energy.

This paper is a preliminary report from a series of experiments undertaken to examine the effect of a supplementary energy supply on urea metabolism and rumen function in sheep fed fresh lucerne. A sucrose solution was used as the supplementary energy source and administered as a continuous infusion directly into the rumen.

EXPERIMENTAL

Nine rumen fistulated 2-year-old Romney wethers weighing 34 to 42 kg were housed indoors in

individual metabolism cages and fed *ad libitum* on fresh lucerne (*Medicago sativa* cv. Rere) harvested daily at 0830 h. The animals were offered herbage hourly from moving belt feeders for 3 weeks prior to, and during, the experiment.

Five of the sheep (control) were continuously infused intraruminally with water (1200 ml/d); the other 4 sheep (treated) were infused with a similar volume of an aqueous solution of sucrose (160 g/l). All sheep were maintained on infusions for a minimum 8 d prior to and throughout the experiment. Intakes and infusions were measured daily.

Two days prior to the experiment (day 7) intravenous catheters (polyvinyl chloride, 1.0 mm I.D.) were placed in both jugular veins. On day 9 the animals were given an intravenous injection, into 1 catheter, of ^{14}C -urea (80 μCi ; 6 ml) flushed in with 5 ml of 0.9% NaCl. Urea kinetics were estimated from the decline in specific radioactivity of ^{14}C -urea in plasma samples collected over the subsequent 15 h and measurement of urea-N excretion in urine over 48 h. Rumen fluid samples were collected over 4 d for analysis of ammonia-N, VFA content and pH. Faeces and urine output from 2 sheep on each treatment were recorded for 6 d and samples collected for analysis of N excretion and dry matter (DM) and organic matter (OM) output. Analytical methods were similar to those outlined by Ulyatt and MacRae (1974) and Egan and Ulyatt (1980).

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TABLE 1 Intake, rumen fluid indices and urea kinetics in sheep fed on fresh lucerne with or without sucrose supplementation.

Parameter	Infusion treatment		Significance
	Water	Sucrose	
Sucrose infusion (g/d)	—	190	
Intake			
DM (g/d)	972	945	NS
OM (g/d)	868	843	NS
Digestible OM (g/d)	621	783	***
N (g/d)	33.0	32.1	NS
Digestible N (g/d)	24.5	21.9	**
N balance (g/d)	+1.4	+5.5	**
Rumen fluid			
pH	6.6	6.2	*
NH ₃ (mg N/ℓ)	264	142	***
Acetic acid (mM/ℓ)	49	39	***
Propionic acid (mM/ℓ)	28	40	***
Urea kinetics			
Plasma urea-N (mg/ℓ)	258	172	**
Irreversible loss (gN/d)	26.6	26.6	NS
Excretion (gN/d)	18.9	13.0	**
Degradation (gN/d)	7.6	13.0	**
Proportion produced that is recycled (%)	28	50	**

RESULTS AND DISCUSSION

The fresh lucerne diet provided 34 g N, 893 g OM, 35 g lipid and 204 MJ of energy per kg DM. Both control and treated groups consumed similar quantities of the diet and digested similar quantities of dietary DM and OM (Table 1). In addition, the treated group apparently fermented all of the sucrose in the rumen as only normal, low levels, of soluble sugars were detected in abomasal contents of all sheep at the end of the experiment. This increased fermentation reduced rumen fluid pH from 6.6 to 6.2 with no apparent detrimental effect. Indeed, rumen fluid propionic acid levels increased from 28 mM/ℓ to 40 mM/ℓ with a concomitant decrease in acetic acid from 49 mM/ℓ to 39 mM/ℓ.

Although N intakes were similar in both groups, N kinetics in the gut and at the tissue level differed (Table 1). Apparent absorption of N was lower in the treated group (digestible N intake 24.5 v 21.9 g N/d) and yet the treated group retained more of the absorbed N at the tissue level.

Part of this difference in N metabolism can be attributed to events in the forestomach. Rumen fluid ammonia levels were lower in the treated group but were associated with a higher degree of rumen microbial activity, coupled with an increase in urea recycling to the gut, suggesting an increase in microbial protein production through utilisation of ammonia-N. Kennedy (1980) also observed lower rumen ammonia concentration, increased urea

recycling, and an increase in microbial protein flow through the abomasum, in cattle fed good quality dried diets with added sucrose. Similarly, Rooke *et al.* (1987) determined an increase in microbial protein flow to the small intestine in cattle fed a grass-silage diet when supplemented with an intraruminal infusion of either glucose or glucose plus casein. In the present experiments the treated group excreted more N in the faeces, due probably to an increase in undigested rumen microbial cell residues and, perhaps, to more microbial cells produced in the hindgut, if part of the increased urea degradation was due to hindgut microbial activity.

The increase in tissue retention of N in the treated group was probably enhanced by increased propionate utilisation for glucose production. In a subsequent experiment D.W. Dellow, Y. Obara, K.E. Kelly and B.R. Sinclair, (unpublished) with sheep fed chopped lucerne hay we found, as in the present experiment, that intraruminal supplementation with similar amounts of sucrose increased the propionic acid levels in the rumen (17 v 29 mM/ℓ) suggesting that propionic acid production *per se* was greater. This was accompanied by an increase in plasma glucose irreversible loss rate (113 v 188 g glucose/d). Since ruminants absorb very little glucose from the gut, most of their glucose requirements must be synthesised from propionate and protein. In the present experiment it appears that the increased fermentation of organic matter in the rumen produced more propionate which in turn

contributed to, and increased, glucose production as also reported by Gill *et al.* (1982) thus reducing the requirement for glucogenic amino acids for glucose production.

CONCLUSIONS

In the present study the overall effect of a readily fermentable supplementary energy supply in sheep fed fresh lucerne was to improve the efficiency of utilisation of the dietary-N consumed. The effect appears to be synergistic; more ammonia-N was utilised by rumen microbes, more propionic acid was produced and absorbed amino acids were utilised more efficiently for protein metabolism. It is suggested that correctly designed supplementary feeds could be used to improve utilisation of pasture herbage and improve growth rate in young sheep. Strategic supplementation to match pasture type, and availability, would allow a more predictable response as liveweight gain.

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