THE EFFECT OF LACTIC ACID ON THE MICROBIAL PROTEIN SYNTHESIS IN THE RUMEN OF CATTLE

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Introduction

The use of fermentation stimulants (enzymes, bacterial inoculants) as silage additives is producing silages with high lactic acid content. It can be estimated that the high concentration of fermentation acids results in a 15-20% reduction in the energy yield for rumen microbes as compared with the silage of restricted fermentation (Chamberlain, 1987). It has been suggested that this might be one reason for the low values of the efficiency of microbial protein synthesis in the rumen of animals given silage diets. The purpose of the present experiment was to study the effects of the gradual replacement of sucrose with lactic acid on the rumen fermentation and the microbial protein synthesis.

Materials and Methods

A 3x3 Latin square experiment was carried out with three bulls (initial weight 212 kg) each fitted with a rumen fistula and a simple T-piece cannula in the proximal duodenum. The basal diet offered at the mean level of 3.8 kg DM/d consisted of grass silage (700 g/kg DM) and barley-rapeseed meal (4:1) -mixture (300 g/kg DM). The content of nitrogen, lactic acid and water soluble carbohydrates in the silage was 29, 40 and 39 g/kg DM, respectively. In one treatment the diet was supplemented with sucrose (S) at the level of 120 g/kg of the basal diet DM intake. In the other two treatments either half (SLA) or all (LA) of the sucrose was replaced with lactic acid (LA) (hexose equivalent basis) with the daily allowance of 230 or 460 g, respectively. Basal diet and sucrose were offered in two equal meals at 12 h intervals. LA-solution (pH 4) was infused into the rumen.

The flow of digesta to the duodenum was estimated with a double marker method with Cr-mordanted straw administered via a rumen cannula as a particulate marker and LiCoEDTA infused intraruminally as a liquid marker. The efficiency of microbial protein synthesis in the rumen and microbial-N flow to the duodenum were estimated with purine bases as a microbial marker.

Results and Discussion

The inclusion of LA in the diet increased linearly ($P < 0.05$) the mean rumen pH (table 1). The minimum pH was 5.6 with diet S, whilst with diet LA the rumen pH was maintained above 6.0 during the whole feeding cycle. Also the peak in the lactic acid concentration in the rumen after feeding was markedly higher with S diet (19.4 mmol/l) than with LA diet (1.2 mmol/l). The low concentration of lactic acid with LA diet suggested that there might have been some adaptation leading to a very rapid fermentation of lactic acid to VFA. The molar proportion of propionate of the

TABLE 1. THE CHARACTERISTICS OF RUMEN FERMENTATION

	Diets			SEM	Stat. sign.[1]
	S	SLA	LA		
pH	5.93	6.15	6.44	0.06	*
Protozoa (10^5/ml)	6.8	5.8	4.1	0.7	NS
NH_3-N (mmol/l)	9.64	11.21	9.29	1.69	NS
Lactic acid[2] (mmol/l)	6.05	1.37	0.55	0.84	*
Tot.VFA (mmol/l)	111.1	118.3	108.5	4.14	NS
Molar prop. of VFAs (mmol/mol)					
Acetic acid	593	599	609	8.01	NS
Propionic acid	179	225	226	6.95	*
Butyric acid	189	144	134	6.61	*

[1] Stat. signif. of this linear effect of LA-level, *$p < 0.05$.
[2] Lactic acid samples 0-4 h after feeding, others 0-10 h.

VFA mixture increased linearly ($P < 0.05$) and that of butyrate decreased linearly ($P < 0.05$) with increasing LA level. These changes indicated that propionate was the main end-product of lactic acid fermentation, being in good agreement with the results of Chamberlain et al. (1983). In contrast, isotope tracer studies showed that acetate was the main end-product of lactic acid fermentation in sheep given grass silage (Gill et al., 1986).

The quantities of total N and non ammonia-N (NAN) entering duodenum decreased linearly ($P < 0.05$) with increasing LA level. On the other hand, although the energy yield from the fermentation of lactate could be expected to be smaller than that from sucrose, no significant differences were observed in the amount of microbial N flowing to the duodenum or in the apparent efficiency of microbial N synthesis in the rumen (table 2). Increased loss of N between mouth and duodenum suggested that microbial incorporation of ammonia N reduced with increasing level of LA. Lower purine:N ratio in rumen protozoa than in bacteria (Firkens et al., 1987) together with the trend ($P < 0.1$) of the number of rumen protozoa to increase with increasing level of sucrose may explain the lack of the difference in the estimated microbial flow. The absence of difference in the rumen ammonia N concentration may reflect enhanced absorption with the diet LA because of the higher rumen pH rather than equal microbial incorporation.

TABLE 2. DIGESTION OF NITROGEN

	Diets			SEM	Stat. sign.
	S	SLA	LA		
In feed (g/d)	114.6	116.0	115.7	1.0	NS
At duodenum (g/d)					
NAN	97.9	96.0	90.9	0.4	*
Microbial N	67.4	69.4	66.8	1.0	NS
In faeces (g/d)	28.7	28.7	28.3	0.4	NS
NAN at duodenum/ N intake	0.84	0.83	0.79	0.004	*
Microbial N g/ kg OMADR[1]	29.5	30.1	28.9	0.03	NS

[1] OMARD = organic matter apparently digested in the rumen.

(Key Words: Lactic Acid, Rumen Fermentation, Protein Synthesis)

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