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COTTONSEED MEAL AS A SOURCE OF N FOR RUMEN MICRO-ORGANISMS IN SHEEP GIVEN A MOLASSES-BASED DIET

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An experiment was carried out to determine whether the use of relatively high levels of cottonseed meal (CSM) as a supplement to molasses-based diets could supply sufficient NH_3 for maximal microbial growth in the rumen. Four sheep with rumen cannulae were given molasses ad libitum and 200 g pelleted straw/d as the basal diet. Dietary treatments consisted of supplements of 50, 100, 200 and 300 g CSM/d compared to urea included at 2.5 and 5% (w/w) in the molasses. Each treatment period was for 7 d and there were two control periods when only the basal diet was fed. Dietary intake, rumen NH_3 and volatile fatty acid concentrations were measured during each period. There was no significant effect of level of CSM on rumen NH_3 concentration (mean 3.5 mg NH_3/100 ml rumen fluid), but the addition of 2.5 and 5% urea to the molasses significantly increased rumen NH_3 to 7.6 and 22.3 mg/100 ml respectively. It was concluded that CSM is a good source of rumen undegradable protein but even with CSM supplementation it is necessary to include urea in the molasses to ensure efficient rumen fermentation and thus maximise microbial protein synthesis.

Key words : Molasses, urea, cottonseed meal, rumen ammonia

Rumen bacteria use NH_3 as a principal source of N for protein synthesis and growth. In most situations it is cheaper to feed ruminants non-protein N (NPN) sources such as urea, than to rely on the breakdown of feed protein to NH_3 during rumen fermentation to provide a supply of soluble N for microbial growth. The protein synthesised by rumen micro-organisms often provides more than 50% of the protein available to the host animal, and it is therefore important to provide the nutrients in the diet to optimise this process. The principles governing the utilization of NPN by ruminants have been reviewed by several authors (eg. Satter & Roffler 1977). It appears to be well accepted that a dietary balance is required between fermentable organic matter for microbial fermentation and a source of N, principally as NH_3, for protein synthesis. It was shown by Satter & Slyter (1974) that a concentration of at least 5 mg NH_3 -N/100 ml of rumen fluid was required for maximal microbial growth. When molasses is fed to cattle as the major energy source, urea is normally incorporated in the molasses at the rate of 2.5% (w/w), the level shown to give optimal animal growth rate and feed conversion efficiency (see Preston 1972).

There may be certain circumstances, however, in which the cost of including urea in the diet may be greater than that of a protein-rich oil seed cake. This may occur in areas where oil seeds are processed for the extraction of oil and the high protein by-product either sold back to the producer, or used by the factory in an integrated feedlot

enterprise. In such instances it is argued that high levels of protein meal in a molasses-based feeding system may replace the requirement for dietary urea.

The purpose of this experiment was to determine whether feeding high levels of cottonseed meal (CSM) to sheep with free access to molasses (with no added urea) could provide sufficient rumen NH_3 for maximal microbial protein synthesis.

Materials and Methods

Animals and dietary treatments: Four mature sheep weighing 35 - 40 kg were given a diet consisting of 200 g pelleted straw fed each morning, and free access to cane molasses for the remainder of the day. This control diet was fed for 6 weeks before the first experimental period. There were eight dietary treatments, each of 7 days:

(i) control diet : 200 g pelleted straw + molasses ad libitum
(ii) control diet + 50 g CSM/d
(iii) control diet + 100 g CSM/d
(iv) control diet + 200 g CSM/d
(v) control diet + 300 g CSM/d
(vi) control diet
(vii) 200 g pelleted straw + molasses (with 2.5% urea) ad libitum
(viii) 200 g pelleted straw + molasses (with 5% urea) ad libitum

Measurements: The daily intakes of molasses, straw and CSM were measured. During the last two days of each treatment period two samples of rumen fluid were taken; the first, 1 hr after feeding the straw and CSM, and the second, 6 hr after feeding. Each sample of rumen fluid was analysed for NH_3 concentration, total volatile fatty acid (VFA) concentration, and the molar proportions of each major VFA.

Analytical methods: Rumen NH_3 concentration was estimated colorimetrically by the method of Chaney & Marbach (1962). The concentration of total VFA and the molar proportions of acetate, propionate and butyrate were measured by gas-liquid chromatography using 3-methylvaleric acid as an internal standard. A 1.5 m glass column packed with 'Supelco 1-2144' (15% SP 1220, 1% H_3PO_4 on 100/120 Chromosorb W AW) was used to separate the VFA, with argon as the carrier gas and concentration determined by flame ionization. The column temperature was maintained between 140-150° and the injector temperature, 250°C.

Results

The daily DM intakes of the different dietary components, measured over the final 2 days of each experimental period, are given in Table 1. Also shown are the total rumen VFA concentrations and the molar proportions of acetate, propionate and butyrate, measured during the

Table 1:

Dry matter intake, total concentration of VFA in rumen fluid and the molar proportions of acetate, propionate and butyrate measured in sheep given a diet of pelleted straw (93% DM) and molasses (75% DM) supplemented with either CSM (92% DM) or urea.

Dietary Component	Control	g CSM/d				Urea in molasses			Pooled $SE_{\bar{x}}$
		50	100	200	300	Control	2.5%	5.0%	
DM Intake (g/d)									
Pelleted straw	186	186	186	186	186	186	186	186	-
Molasses	412	312	652	715	682	628	762	805	90
CSM	-	46	92	184	276	-	-	-	-
Urea	-	-	-	-	-	-	2	42	-
Total	598	544	930	1085	1144	814	950	1033	90
Rumen VFA conc'n (mmol/l)	56	59	91	95	104	76	74	87	6.9
% acetate	65	62	57	64	59	66	63	61	2.6
% propionate	14	17	22	22	28	24	27	29	4.7
% butyrate	16	18	18	12	11	7	8	8	3.0

Table 2:

Intake of N and rumen NH_3 concentration measured in sheep given a basal diet of pelleted straw (0.80% N) and molasses (0.67% N) supplemented with different levels of CSM (6.91% N) or urea.

Dietary Component	Control	g CSM/d				Urea in molasses (%)			Pooled $SE_{\bar{x}}$
		50	100	200	300	Control	2.5	5.0	
Intake of N (g/d)									
Straw	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	-
Molasses	2.76	2.09	4.37	4.79	4.59	4.21	5.11	5.39	0.60
CSM	-	3.18	6.36	12.71	19.07	-	-	-	-
Urea	-	-	-	-	-	-	8.76	18.52	0.98
Total	4.25	6.76	12.12	18.99	25.13	5.70	15.36	25.40	1.15
Rumen NH_3 (mg/100 ml)	3.5	3.3	2.9	3.8	3.8	2.7	7.6	22.3	0.8

same period. The total VFA concentration in the rumen appeared to respond positively to increased total DM intake. There were no significant differences between sampling times in any of the rumen parameters measured and mean values are given. There was a significant ($P < 0.05$) increase in the intake of molasses between the first two experimental periods and those measured during the remainder of the trial.

The intake of N and the concentration of rumen NH_3 measured during the final 2 days of each dietary treatment period, are shown in Table 2. Without urea in the diet there was no significant change in the rumen NH_3 concentration associated with changes in N intake (mainly CSM-N) ranging from 4.25 to 25.13 g N/d. The concentration of rumen NH_3 increased significantly ($P < 0.01$), when urea was included in the molasses at 2.5 or 5%, relative to when the control diet was fed. There was also a significant ($P < 0.01$) increase in rumen NH_3 concentration when the level of urea in molasses was raised from 2.5 to 5%.

Discussion

In this experiment CSM did not appear to provide a good source of N as NH_3 for microbial protein synthesis in the rumen. Even when relatively large amounts of CSM were eaten, the concentration of rumen NH_3 was still lower than the optimal level for microbial growth proposed by Satter & Slyter (1974). The degradability of the N in CSM, measured by the nylon bag technique was estimated to be between 50 and 75%, depending on the correction factor for rate of rumen fluid turnover (Ørskov et al 1980a). However, assuming that 50% of N in the 300 g CSM fed was degraded in the rumen, approximately9.5 g N would pass through rumen NH_3. This is more than that provided by the inclusion of urea at 2.5% in molasses (8.8 g urea-N/d) but only resulted in half the concentration of rumen NH_3 (3.8 vs 7.5 mg NH_3/100 ml). One of the limitations of the nylon bag technique is that the parameter actually measured is the breakdown of the feed in the bag into fine enough particles to pass out of the bag, not the complete degradation of the materials into the simple compounds which are the end-products of fermentation (Ørskov et al 1980b). It therefore seems possible that a large proportion of the CSM protein may pass from the rumen undegraded, in the form of fine particles. In other studies with cattle fed high energy, low protein diets (e.g. Meyreles et al 1979), CSM supplementation produced a significant increase in growth rate even when urea was included in the diet. These authors also suggested that this response to CSM was due to its properties of low rumen degradability.

The results presented here indicate that even in situations where CSM is cheaper than urea as a source of N, and may economically be fed in large amounts, it is still necessary to add urea (or some other source of readily available NH_3-N) to molasses-based diets to provide sufficient

rumen NH_3 for microbial protein synthesis. The response in animal performance to increasing levels of dietary protein, of low rumen degradability, when molasses is fed ad libitum is well understood (Preston & Willis, 1974), and it is possible that by supplying sufficient dietary protein the importance of efficient rumen microbial protein synthesis may be diminished. However, if there is a low availability of N for rumen bacteria, the overall rate of fermentation is likely to be reduced and the availability of metabolisable energy and not protein may be the factor limiting animal performance.

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