STUDIES ON THE DIGESTION IN THE FORESTOMACHS OF CATTLE OF A DIET BASED ON SISAL PULP: I SUPPLEMENTATION WITH LEUCAENA LEUCOCEPHALA AND RICEPOLISHINGS[1]

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Four bulls (3 Brown Swiss x Zebu and I Zebu), weighing about 240 kg and fitted with permanent cannulae in the rumen and duodenum were used in an experiment of Latin square design. The four dietary treatments were: (i) the basal diet of ensiled sisal pulp-plus-urea added at the rate of 8 g/kg sisal pulp; (ii) the basal diet supplemented with 1 kg of rice polishings; (iii) supplementation with 5 kg of Leucaena leucocephala forage; and (iv) supplementation with both rice polishings and leucaena forage. Experimental periods were of 21 d duration. During the last 4 d, Cr-EDTA and Na2 SO4 were infused into the rumen (by injections every 6 hr) in order to estimate the flow of nutrients to the duodenum and the synthesis of microbial protein. The volume and the rate of flow of rumen fluid were estimated from the rate of decline in concentration of Cr-EDTA in rumen fluid, following a single intraruminal injection. The total intake of DM on the diets containing supplements was higher than on the basal diet. The intake of ensiled sisal pulp was similar for all dietary treatments, variations in intakes being due to the intake of the supplements.

There was no effect of supplementation on either rumen fluid volume or rate of turnover. The flow of N to the duodenum increased when either supplement was given. In the case of rice polishings, this appeared to be due to an increase in the amount of dietary protein passing unfermented from the rumen. The effect of leucaena forage was to increase the amount of OM fermented in the rumen and also the quantity of microbial protein synthesized. When both supplements were given, the intake of fermentable OM was highest, but this also resulted in an inefficient synthesis of microbial protein. From the results of this experiment, it was concluded that the feeding of leucaena forage and rice polishings together would not result in an efficient utilization of the protein component of the diet.

Key Words: Ensiled sisal pulp, leucaena, rice polishings

Responses in production to the feeding of Leucaena leucocephala have been reported on molasses based diets (Hulman et al 1978), in cattle fed sugar cane (Alvarez et al 1978), and also in grazing dairy cows (Flores Ramos 1979). In view of the high yields per unit area of leucaena (see Hutton and Beattie 1976) and the high cost of concentrate feeds in most tropical countries, the feeding of leucaena forage to replace concentrates appears attractive. The objective of the present experiment was to investigate the effects of supplements of leucaena and rice polishings on the digestion of a basal diet of ensiled sisal pulp. This was achieved by measuring parameters of rumen fermentation and fluid turnover, in addition to studying the flow of nutrients to the duodenum.

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Materials and Methods

Animals, Dietary Treatments and Design: Four bulls (three Brown Swiss x Zebu and one Zebu), initially weighing about 240 kg, were surgically prepared with permanent cannulae in the rumen and duodenum. The latter were T-shaped cannulae of approximately 25 mm internal diameter. The bulls were housed individually in pens with slatted flooring in an open-sided shed, and had free access to water at all times.

The four dietary treatments were: (i) a basal diet of ensiled sisal pulp with 8 g urea/kg pulp; (ii) the basal diet supplemented with 1 kg of rice polishings/d; (iii) supplementation with 5 kg leucaena/d; and (iv) both supplements of rice polishings and leucaena given together. The sisal pulp was ensiled for 21 d before being fed. The leucaena forage was cut each day and the stems separated by hand so that only the leaves and small twigs (< 5 mm diameter) were fed. Rice polishings were obtained locally, and contained some cracked rice grains as described by Priego et al (1979).

The experiment was of Latin square design with each period being 21 d. The sisal pulp was offered ad libitum during the first 10 d of each period, and subsequently at 110% of the mean intake during these initial 10 d. A mixture of salt and minerals (100 g/d; 505 NaCl, 50% commercial mineral mixture) was also fed to each animal. Feed refusals were weighed each morning before feeding the supplements. The sisal pulp silage was given after the supplement was consumed.

Experimental Procedures: A single injection of Cr-EDTA (100 µCi) in 500 ml of water was distributed throughout the rumen, using a plastic tube, before the morning feed was offered. Samples of rumen fluid were obtained from the dorsal sac immediately before dosing and 8 times during the following 24 hr period. The pH of the rumen fluid was measured immediately before feeding and at 3 hr and 6 hr after feeding the supplements. Approximately 10 ml of rumen fluid was acidified with concentrated H2SO4 and stored at -10!C for the analysis of NH_3 concentration.

For 4 d following the single injection sampling described above, a mixture of Cr-EDTA (25 µCi/d) and Na2 SO (125 µ Ci/d) was injected into the rumen at intervals of 6 hr. For the test 24 hr of this 4 d period, digesta were collected from the duodenal cannulae for 60 min each 4 hr. The sample was weighed and then mixed thoroughly before taking a subsample (10% of the total sample). The remaining digesta was returned through the duodenal cannula over a 15-30 min period. Two separate samples (20 ml) were taken from the subsample for analysis of Cr-EDTA before it was bulked with other subsamples and stored at 5°.

Laboratory Procedures: : Samples for estimation of dry matter (DM) and organic matter (OM) were dried to constant weight at 103! and subsequently ashed in a muffle furnace at 550!. Nitrogen was determined by standard Kjeldahl procedure. NH_3-N in rumen liquor was estimated by distilling 10 ml of rumen fluid with 10 ml of a saturated sodium tetraborate solution and collecting the evolved ammonia in the indicator trapping solution used for total N determinations. The method chosen for analysis of "-linked glucose polymers in duodenal digesta was that of MacRae and Armstrong (1968) using the enzyme preparation "AGIDEX" (Glaxo Ltd., England) to produce glucose which was measured using the Boehringer glucose estimation kit (Bohering, Mannheim, West Germany).

The concentration of ^{51}Cr-EDTA in rumen fluid was estimated by counting 1 ml rumen fluid with 10 ml scintillant (NE 260) in a gama/ beta counter (Nuclear Enterprises NE 8312) The kinetics of rumen fluid were estimated from the decline in ^{51}Cr-EDTA concentration with time, using standard techniques (see Shipley and Clarke 1972). The flow of fluid to the duodenum was estimated by assuming that conditions of continuous infusion were approximated by the injection of ^{51}Cr-EDTA every 6 hr (see Faichney 1975). The flow of DM to the duodenum was estimated from the rate of fluid flow and the DM content of the digesta.

The methods used for measuring the flow of microbial protein to the duodenum, based on the incorporation of $^{35}SO_4$ during microbial synthesis, have been described by Elliott et al (1978).

Table 1:
Intake of the four diets and the flow of DM and OM to the duodenum

	Dietary supplement			
	Basal	+ Rice polishings	+ Leucaena	+ Rice polishings + Leucaena
Intake, kg/d				
Ensiled sisal pulp	14.2	13.8	12.4	14.5
Rice polishings	-	1.0	-	1.0
Leucaena forage	-	-	5.0	5.0
Total intake, kg/d				
DM	3.1	3.9	4.5	5.8
OM	2.7	3.5	4.1	5.4
Duodenal flow, kg/d				
DM	1.6	2.7	2.5	2.7
OM	1.5	2.5	2.3	2.5
α-linked polymers	0.03	0.39	0.04	0.36

Results

The voluntary intake of the individual components of the four dietary treatments are presented in Table 1. The intake of ensiled sisal pulp did not change between diets, with the increases in DM intake being due to the intake of the supplements. There were no refusals of the supplements during the experiment. Flows of m-linked glucose polymers to the duodenum were far higher when rice polishings were included in the diet. The DM contents of the dietary components were: ensiled sisal pulp 21%; leucaena 38%; and rice polishings 95%.

Table 2:
Rumen volumes, the flow of fluid from the rumen, and the turnover rate of rumen fluid estimated on the four dietary treatments

	Dietary supplement			
	Basal	+ Rice polishings	+ Leucaena	+ Rice polishings + Leucaena
Rumen volume, l	28.5	29.7	28.7	29.0
Fluid flow, litres/d	49.2	50.4	53.3	50.5
Turnover, vol/d	1.7	1.7	1.9	1.8

The estimated rumen fluid volumes and rates of flow on the various treatments are shown in Table 2. There were no differences in either the fluid volume or the rate of flow from the rumen, when the sisal pulp was given on its own or supplemented. The pH of rumen fluid was relatively constant (pH 6.9 to 7.0) in all animals on all diets.

Table 3:
Intake of N, concentration of NH_3 in rumen fluid and the flow of N to the duodenum

	Dietary supplement				SEx
	Basal	+ Rice polishings	+ Leucaena	+ Rice polishings + Leucaena	
Intake of N, g/d					
Urea	22	19	18	21	-
Total	56	74	112	143	-
Duodenal flow, g N/d	37	64	70	79	10
Rumen NH_3, mg NH_3-N/litre	130	176	156	200	30

The intake of N, the concentration of NH in rumen fluid, and the flow of N to the duodenum are given in Table 3. The intake of N increased as a result of supplementation and this was also associated with a corresponding increase in the amount of N flowing to the duodenum. The proportion of duodenal N arising from microbial synthesis in the rumen, estimated from the infusion of Na2 SO4 into the rumen, is shown in Table 4.

Table 4:
Proportion of duodenal N of microbial origin, and the efficiency of microbial protein

	Dietary supplement			
	Basal	+ Rice polishings	+ Leucaena	+ Rice polishings + Leucaena
Proportion of duodenal N of microbial origin, %	76	62	80	60
Net synthesis of microorganisms, g N/d	28	39	56	47
OM fermented in the rumen[1], kg/d	1.49	1.39	2.32	4.23
Efficiency of synthesis, N/100 g OM fermented	1.88	2.81	2.41	1.11

[1] Estimated by assuming microbial N to represent 10% of total microbial OM and this OM also to be "fermented" OM

Discussion

The supplements of leucaena forage or rice polishings either alone or in combination did not increase the voluntary intake of ensiled sisal pulp. The increases in total feed intake were attributed to the intake of supplement in addition to the basal ration.

Although the duodenal flow of N appeared to increase in response to increased dietary N intake irrespective of the form of the supplement, it seems that the two supplements did in fact act differently. The feeding of rice polishings resulted in a lower proportion of duodenal N arising from microbial protein synthesis than on the basal diet, indicating the supply of dietary protein to the duodenum, bypassing rumen fermentation. The feeding of leucaena increased the flow of N to the duodenum, above that estimated for the basal diet without altering the proportion of N arising from microbial synthesis,

The reasons for the wide variation in the efficiency of microbial synthesis are not clear. One of the most important factors affecting the efficiency of microbial synthesis has been shown to be the rate of turnover of the rumen fluid (Stouthamer and Bettenhausen 1973; Isaacson et al 1975). However, in this experiment there were no differences observed in the turnover rates of the rumen fluid in response to the different dietary treatments.

It is therefore suggested that the variable extent of degradation of the two supplements in the rumen and the effect that this may have on the availability of nutrients for microbial synthesis could be the main factor affecting the efficiency and amount of microbial synthesis. When rice polishings were given as the only supplement, there was no increase in the amount of OM fermented in the rumen, while, in the case of supplementation with leucaena, there was a significant increase. in the quantity of OM fermented in the rumen and this was associated with an increase

in the amount of microbial synthesis. When both supplements were given together, there was the highest level of OM fermented in the rumen and the lowest efficiency of net microbial production, The fact that rumen NH_3 concentration was also highest suggests that there was considerable hydrolysis of protein, possibly representing the degradation of microorganisms.

Although both supplements fed together resulted in the highest intake of fermentable OM, it is clear that for the most efficient utilization of dietary protein, the use of the supplements individually is to be recommended.

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