

STUDIES ON THE DIGESTION IN THE FORESTOMACHS OF CATTLE OF A DIET BASED ON SISAL PULP: II SUPPLEMENTATION WITH RAMON (BROSIMUM ALICASTRUM) FORAGE AND RICE POLISHINGS¹

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Three crossbred bulls (Zebu x Brown Swiss) weighing about 230 kg and fitted with permanent rumen and duodenum cannulae were used in an experiment of Latin square design. The three dietary treatments consisted of a basal diet supplemented with (i) 1 kg rice polishings; (ii) *Brosimum alicastrum* forage given (as fresh matter) at 2% of animal liveweight/d; and (iii) both supplements given together. The basal diet consisted of ensiled sisal pulp fed ad libitum with 8 g urea/kg pulp. Estimates were made of feed intake, volume and turnover rate of rumen fluid, and, the flow of various nutrients to the duodenum.

The intake of sisal pulp was reduced by about 25% when *Brosimum* forage was included in the diet. The pH of the rumen fluid was relatively high (7.1 to 7.4) and did not differ between diets. There were no significant differences in rumen fluid volumes (38 to 47 litres) or in the turnover rates (1.64 to 2.15 volumes/d) between treatments. The flow of α -linked glucose polymers to the duodenum was significantly higher ($P < .001$) when rice polishings were present in the diet (429 against 26 g/d). The concentration of rumen NH_3 and the quantity of OM apparently fermented in the forestomachs were both higher when *Brosimum* forage was given, indicating considerable degradation of this forage in the rumen.

When both supplements were given together, there appeared to be an increase in the flow of N to the duodenum above that which was expected from relationships between N intake and duodenal flow of N obtained for either supplement individually. It was suggested that this was due to an increase in the efficiency of microbial synthesis resulting from improved availability of fermentable OM from the rice polishings, and a greater availability of N compounds (NH_3 and amino acids) from the fermentation of the forage. The ensiled sisal pulp appeared to be a poor source of fermentable OM and it was concluded that for the efficient utilization of supplements of high protein forage, a supplement containing high levels of fermentable energy should also be included in the diet.

Key Words: Ensiled sisal pulp, *Brosimum* forage, rice polishings

It is clear that to obtain acceptable levels of animal production using by-products of tropical agriculture or forage sources which are low in protein and high in fibre, some form of supplementation of the basal diet is required. Preliminary investigations on the feeding of ensiled sisal pulp (*Agave fourcroides*) to cattle (Ferreiro et al 1978) showed that when urea and minerals were the only additions to the basal diet, the animals lost weight.

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On the Yucatan Peninsula, there are two forages which grow throughout the year, are drought resistant, and contain high levels of crude protein. These are known locally as Ramon (*Brosimum alicastrum*) and Huaxin (*Leucaena leucocephala*).

The objective of this experiment was to compare the effectiveness of *Brosimum* forage with that of rice polishings, when given as supplements to a diet based on ensiled sisal pulp. Rice polishings given with chopped sugar cane to cattle have consistently resulted in good rates of liveweight gain (Preston et al 1976). It appears that the rice polishings provide considerable quantities of starch which are not degraded in the rumen (Elliott et al 1978), and it is thought that this contribution of metabolizable energy post-ruminally may explain the growth response. In this experiment, bulls fistulated at the duodenum were used to measure the flow of protein, starch and dry matter (DM) from the forestomachs associated with the feeding of the two supplements individually and together.

Materials and Methods

Animals: Three bulls (Zebu x Brown Swiss) of approximately 230 kg liveweight and prepared with permanent cannulae in the rumen and proximal duodenum, were used in an experiment of Latin square design (3 x 3). The animals were housed in individual pens with slatted floors.

Dietary Treatments: : The basal diet of ensiled sisal pulp plus urea (8 g urea/kg fresh pulp) was given ad libitum. A mineral mix was given daily to the animals (50 g/animal) and water was available at all times.

The three dietary treatments consisted of the basal diet supplemented with (i) *Brosimum* forage (on a fresh matter basis) given at 2% of the animal's liveweight/d; (ii) 1 kg of rice polishings/d; and (iii) both of these supplements given together.

The forage was cut daily and the large stems separated by hand so that only the small twigs and leaves were fed. Rice polishings were obtained locally and were of the same type as used by Elliot et al (1978).

Experimental Procedures: : Feed refusals were collected and weighed each day before feeding the supplement portion of the diet. The ensiled sisal pulp was fed after the supplement had been consumed.

The measurements of parameters of rumen function and of the flow of nutrients to the duodenum commenced after the bulls had been fed the dietary treatments for at least 14 d.

The procedure for estimating the rate of flow of DM and N to the duodenum and also the volume, rate of turnover, and the pH of rumen fluid were described previously (Priego et al 1979). In this experiment, Cr-EDTA was used as the marker to estimate the duodenal flow rate and Polyethylene glycol (PEG) (Carbowax 4000) was used as the rumen fluid tracer.

Analyses: The method used for the determination of Cr was that reported by Stevens and de Langen (1960). PEG determination was carried out using the method described by Priego et al (1977). Other analytical procedures used have previously been described (Priego et al 1979).

Results

The intake of the different components of the diets and the rates of passage of DM, organic matter (OM), N and α -linked glucose polymers to the duodenum are given in Table 1. There were no significant differences between treatments in the quantity of OM passing to the duodenum, except when both supplements were given together. When rice polishings were given in the diet, there were substantially higher levels of α -linked glucose polymers flowing to the duodenum, than when only Brosimum forage was given. The flow of N to the duodenum when both supplements were given was significantly higher ($P < .01$) than when either supplement was fed on its own.

Table 1 :
Mean intakes of dietary components, and passage to the duodenum of DM, OM, N and α -linked glucose polymers in cattle given diets based on ensiled sisal pulp

	Supplement			SE _x
	Rice polishings	Brosimum forage	Rice polishings and forage	
Intake, kg fresh matter/d				
Ensiled sisal pulp	10.4	7.8	7.4	
Brosimum forage-	-	5.8	5.3	
Rice polishings	1.0	-	1.0	
Total intake				
DM, kg/d	3.39	4.45	4.96	
OM, kg/d	2.97	4.16	4.70	
N, g/d	61	145	152	
Duodenal flow				
DM, kg/d	2.15	1.84	2.68	.17
OM, kg/d	1.75	1.40	2.07	.10
N, g/d	48	45	79	3.5
α -linked polymers, g/d	429	26	416	12

The pH of rumen fluid was relatively high (pH 7.1 to 7.4) and did not differ significantly between animals or when the different rations were given. Table 2 shows the concentration of NH_3 in rumen fluid and the estimated volumes and turnover rates of rumen fluid. Rumen NH_3 concentration was higher when the diets containing Brosimum forage were fed, than when only rice polishings were given as the supplement. There were no significant differences between dietary treatments in the rumen volumes or in the rates of rumen fluid flow and turnover.

Table 2.
Rumen fluid NH_3 concentration, volume, flow rate and turnover rate

	Supplement			SE _x
	Rice polishings	Brosimum forage	Rice polishings and forage	
Rumen NH_3 , mg NH_3 -N/litre	86	156	166	7.2
Rumen fluid				
Volume, litres	40	38	47	6.2
Flow rate, litres/d	86	72	77	11.4
Turnover rate vol/d	2.15	1.89	1.64	0.15

Discussion

The addition of rice polishings to the basal diet of ensiled sisal pulp plus urea resulted in considerable flows of a-linked glucose polymers to the small intestine. This is similar to the results obtained by Elliott et al (1978). The decrease in the intake of ensiled sisal pulp when Brosimum forage was given was not observed in a previous experiment in which leucaena forage was given as a supplement to the same basal diet (Priego et al 1979). In that experiment, the addition of the forage had no effect on the intake of sisal pulp when it was compared with the effect of rice polishings as a supplement, or the basal diet given on its own.

The addition of Brosimum forage to the diet in place of rice polishings produced very little change in total N flows to the duodenum, but when the two supplements were combined, a substantially higher level of total N entering the small intestine was observed. It would appear that the Brosimum forage is highly degradable in the rumen, since there was both a higher concentration of rumen NH_3 when Brosimum forage was included in the diet and also more OM fermented in the forestomachs than when rice polishings were given. Both supplements, when given individually, result in similar flows of N to the duodenum, and it is therefore suggested that the supplement of rice polishings results mainly in the supply of bypass protein, in comparison to the forage, which may act to increase the synthesis of microbial protein in the rumen. It appears that when both supplements are given, there is an increase in the efficiency of microbial protein synthesis in addition to a supply of bypass protein from the rice polishings.

There is an increase in N intake of only 8 g/d between the diet containing only Brosimum forage and that containing both supplements, while the corresponding difference in N flow to the duodenum is 34 gN/d. This suggests that the rice polishings in the diet may be an important source of fermentable energy in the rumen, required to achieve a higher efficiency of microbial protein synthesis.

It would therefore seem that supplementation of basal diets of ensiled sisal pulp with high protein forages which are rapidly degraded in the rumen may not result in improved liveweight gains, unless these forages are fed with an energy source which is also partly fermented in the rumen.

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