THE EFFECT OF ENERGY RICH FEED SUPPLEMENTS ON THE AVAILABILITY OF NUTRIENTS IN THE DUODENUM OF CATTLE FED SUGAR CANE[1]

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Three energy rich feed supplements, banana, maize and rice polishings, were given to cattle receiving a basic diet of sugar cane. in order to examine their effect on the supply of protein (N) and α-linked glucose polymers to the animal at the duodenum. Four steers fitted with cannulae in the rumen and duodenum were used. The experimental design wee similar to a 4 x 4 Latin square with four dietary treatments: (i) control (chopped auger cane plus 10g urea/kg fresh cane), with supplements of (ii) 3 kg/d of chopped green banana, (iii) 1 kg/d of ground maize, and (iv) 1 kg/d of rice polishings. Each experimental period was of three weeks duration and in each period all animals received the same supplement.

The flow of duodenal digesta wee measured using Cr-EDTA, and was analysed for N content and α-linked glucose polymers. The feeding of both maize and rice polishings w a associated with a higher ($P < .05$) rate of N flow to the duodenum (37.9 and 50.6 g N/d). Chopped bananas ant maize when given as supplements increased ($P < .05$) the supply of α-linked glucose polymers (174 and 274 g/d respectively) with respect to the rice polishings and the control which were not significantly different (mean 33 g/d). The low level of cr-linked glucose polymers in duodenal digesta on the rice polishings diet wee in contrast to previous findings. It wee shown that this resulted from a low content of rice fragments in the rice polishings compared with the batch of rice polishings used in earlier experiments.

From the results of this experiment and other published work, it was concluded that for a feed supplement to be utilized efficiently to improve animal performance in feeding energy based on sugar cane, it should have the property of providing both protein and energy post-ruminally.

Key Words: Sugar cane, cattle, starch bypass. duodenal cannulae

It has previously been demonstrated by Elliott et al (1978a) that appreciable quantities of α-linked glucose polymers escape rumen fermentation in steers fed a chopped sugar cane diet supplemented with rice polishings. It also appeared that the quantities of total N in the duodenal digesta increased with increasing levels of rice polishings in the diet, and this was attributed to the protein in the rice polishings escaping rumen degradation (Elliott et al 1978b).

Two other feed supplements commonly available in most tropical areas are maize and bananas. The aim of this experiment was to evaluate these products and rice polishings in terms of the effect on microbial synthesis in the rumen and the quantity of α-linked glucose polymers escaping fermentation in the rumen when cattle were fed a diet of chopped sugar cane plus urea.

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Materials and Methods

Animals and Experimental Design: Four Zebu . Brown Swiss steers were used in an experiment of modified Latin square design. Each period was three weeks, and due to the restricted time during which the bananas were available, it was necessary for all animals to receive the same supplement at the same time. All animals had permanent cannulae in the rumen and in the proximal duodenum.

Diet: The basal diet consisted of chopped sugar cane fed at a stalk to tops ratio of 70:30 to maintain the same quantities of tops in each dietary treatment (Ferreiro and Preston 1977). The experimental treatments consisted of a basal diet of chopped sugar cane plus urea (10 g of urea/kg of fresh cane), with or without one of the supplements (fresh matter basis) as follows:

Treatment A 1 kg of rice polishings

Treatment B 3 kg of chopped green bananas

Treatment C 1 kg of ground maize

Treatment D No supplement.

A mixture of salt, dicalcium phosphate and trace elements (50:35:15 w/w) was mixed with the supplement and given before feeding the sugar cane. The sugar content of the sugar cane juice was estimated as °Brix, measured by refractometer.

Estimation of DM Flow to the Proximal Duodenum: For one week before a 24 hr collection of duodenal digesta, which took place at the end of each experimental period, one litre of a Cr-EDTA solution (Binnerts et al 1968) was infused into the rumen of each animal. 500 ml was given at the time of the morning feed and 500 ml at the afternoon feed. The following collection procedure was used to obtain a representative sample of duodenal digesta. During a 5 min period every hour, a heavy-duty plastic bag was attached to the opened duodenal cannula and digesta collected. Each sample taken in this way was weighed and homogenised, before taking a 10% subsample which was stored at 2°C.

Rumen pH and Ammonia Levels: Samples of rumen liquor (10 ml) were taken from each animal every 3 hr during the 24 hr collection period. After measuring pa, the samples were acidified by adding 10 ml of 2 M HCl and were then maintained at -5°C until analysed for ammonia-N concentrations.

Analysis: All samples of duodenal digesta were dried to constant weight at 103°. to determine the DM percentage; the dry matter was subsequently ashed in a muffle furnace at 550° to determine the organic matter (OM) fraction. The chromium determination was that reported by Stevens and de Langen (1960). Nitrogen was determined by the standard Kjeldahl procedure. NH_3-N in rumen liquor was estimated by distilling 10 ml of the rumen fluid/HCl mixture 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 α-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 (Boehring, Mannheim, West Germany).

Results

The mean voluntary intakes (kg DM/d) of the animals fed the four dietary treatments are presented in Table 1. The intake of the sugar cane was similar on all treatments. The sugar content of the cane was consistently high (18-19! Brix) throughout the experiment. There were no refusals of supplement during the entire experiment.

Table 1. The intake of a ration based on sugar cane supplemented with three different energy sources. The °Brix of sugar cane juice is also shown.

	Supplement			
	Chopped banana	Ground maize	Rice polishings	Control
Intake, kg/d				
Sugar cane	13.4	12.5	14.0	12.8
Supplement	3.0	1.0	1.0	-
Urea	0.14	0.13	0.18	0.17
Minerals	0.05	0.05	0.05	0.05
Total DM Intake kg/d	4.35	4.18	4.63	3.41
°Brix in cane juice[1]	19.0	18.5	18.5	18.0

[1] Measured by refractometer

Table 2:
Intake of OM, the flow of OM to the duodenum and its apparent digestibility an the forestomachs.

	Supplement				SEx
	Chopped banana	Ground maize	Rice polishings	Control	
Passage of OM, kg/d					
Intake	3.96	3.79	4.24	2.99	0.09
Duodenal	1.16a	1.60b	1.60b	1.20a	0.34
Apparent digestibility, in forestomachs, %	70.7	57.9	62.2	59.7	9.41

ab Values within rows having different superscripts are significantly (P< 05)

Presented in Table 2 are the mean intakes of OM on all four dietary treatments. Also shown are the quantities (kg/d) of OM passing through the proximal duodenum and the apparent digestibilities of OM in the forestomach. The quantities of OM passing through the duodenum in animals fed supplements of ground maize and rice polishings were significantly greater (P< .05) than when the basal ration or the banana supplemented ration were given.

Table 3 shows the total N intake and the flow of N to the duodenum measured during each 24 hr collection period. The quantities of total N passing to the duodenum have been used to calculate apparent digestibility of N in the forestomachs.

Table 3:
Intake of N, the concentration of N in duodenal digesta and its rate of passage through this organ. Also shown is rumen ammonia concentration.

	Supplement				SEx
	Chopped banana	Ground maize	Rice polishings	Control	
Sugar cane	32.3	29.5	33.8	30.9	-
Supplement	6.9	16.2	20.3	-	-
Urea	64.0	64.1	61.8	77.0	-
Total	103.2	109.8	115.9	107.9	-
Concentration of N in duodenal digesta g/100 g DM	1.9a	2.1ab	2.8c	2.2b	0.02
Duodenal flow g N/d	28.4.	37.9b	50.6c	25.8a	4.5
Rumen NH3,.mg NH3-M/litre	145.0	152.0	140.0	154.0	9.0

When rice polishings were given as the supplement, both the concentration of N in the duodenal digesta and the rate of flow were higher than on any of the other diets studied. While the feeding of maize was also associated with a higher flow of N to the duodenum than on the control diet, there was no effect when bananas were given.

The intake of α-linked glucose polymers and the quantities passing to the duodenum are shown in Table 4.

The α-linked glucose polymer concentration of duodenal digesta from the animals fed the chopped banana or ground maize was significantly higher than that of the same animals fed the control diet without supplement, or the diet with supplementary rice polishings.

The concentration of α-linked glucose in duodenal digesta and its rate of flow from the forestomachs appear to be related to the level of intake of each supplement. However, the apparent digestibility of the α-linked glucose in the forestomachs also influences the rate of flow to the duodenum and in this experiment, it varied from 60% for maize to 82% for rice polishings.

Table 4:
Intake of α-linked glucose polymers, their concentration in duodenal digesta, their rate of flow through the duodenm, and their apparent digestibility in the forestomachs

	Supplement				SEx
	Chopped banana	Ground maize	Rice polishings	Control	
α-linked glucose polymers					
Intake, g/d	597	694	250	-	-
Concentration in duodenal digesta, g/100 g DM	13.1b	15.2b	2.4a	1.6a	4.24
Duodenal flow, g/d	174.0c	274.5d	43.7a	22.0	20.1
Apparent digestibility in forestomachs, %	70.8	60.4	82.5	-	-

Discussion

One of the most important features of these results is the very low level of α-linked glucose polymers passing at the proximal duodenal level of steers fed the basal sugar cane diet with rice polishings as the supplement. These findings are in contrast to the results obtained by Elliott et al (1978a) and Priego et al (1979a; 1979b), who showed that considerable quantities of "-linked glucose polymers passed unfermented from the rumen when rice polishings were fed as a supplement to basal diets of chopped sugar cane or ensiled henequen pulp.

The rice polishings used by Elliott et al (1978a) contained 52% α-linked glucose polymers, whereas the rice polishings used in this experiment (purchased from the same rice processing factory) contained only 23% α-linked glucose. It was suggested by Elliott et al (1978a) that the quantity of starch in rice polishings bypassing rumen fermentation depended on the quantity of broken rice grains present in the supplement. A 2 mm sieve was used to fractionate the rice polishings and both fractions were analysed for total N and α-linked glucose polymers. These procedures were carried out on the rice polishings used by Elliott et al (1978a) and those used in this study. The ground maize was also fractionated in this way. The results are presented in Table 5.

Table 5:
Total N and α-linked glucose polymer concentrations (% in DM) in rice polishings and ground maize before and after separation of their respective fractions using a 2 mm sieve.

Sample	Rice polishing				Ground maize	
	Present experiment		Elliott et al. (1978a)		Present experiment	
	Total N	α-polymers	Total N	α-polymers	Total N	α-polymers
Entire supplement	2.25	27	1.86	52	1.70	73
Particles < 2 mm	2.45	22	2.06	36	1.85	83
Particles > 2 mm	1.84	35	1.45	66	1.39	69

From these results it appears that most of the "-linked glucose polymers in rice polishings are in fact present in the larger particles representing fragments of rice grains. The variability of the size of this fraction is also clear.

The increase in the quantities of α-linked glucose polymers entering the duodenum when maize was given is in agreement with the findings of Waldo (1973) and Elliott and Carpenter (1974), who also reported substantial quantities of starch escaping rumen fermentation when cold rolled maize was fed to cattle.

It is difficult to explain the increase in duodenal N flows due to the rice polishings supplement. Undoubtedly, part of the increase was due to some of the N in the supplement bypassing rumen fermentation (Elliott et al. 1978b). However, even if all the N in the supplement (20.3 g N) bypassed rumen fermentation, this is insufficient to account for the increase of 24.8 g N/d above the control diet. It also does not appear to be a direct effect of increasing the energy available for microbial synthesis since when the bananas were given, there was not an increase in the flow of N to the duodenum even though there was extensive fermentation of this carbohydrate in the rumen.

It has however been suggested that rice polishings increase the efficiency of microbial production in the rumen by influencing changes in rumen turnover rates (Elliott et al 1978b).

From the results presented here and from other published observations, it appears that in order to obtain an efficient response in animal performance to supplementation with either a source of energy or of protein, the feed supplement should contain both good protein and good energy characteristics. For example, Silvestre et al (1976) reported that supplementation of a sugar cane diet with maize alone did not produce a high response level in animal production, until fish meal, a protein of high biological value, was also included in the diet. In another experiment, where only fish meal was used as a supplement to sugar cane, animal growth rates have also been low (Silvestre et al 1977). Of the supplements examined in this experiment, rice polishings was associated with the highest supply of N in the duodenal digesta.

It is suggested that it is this characteristic of the rice polishings, together with the occasional high levels of rice grain providing large amounts of energy post ruminally, that have resulted in the high levels of animal performance reported previously (Preston et al 1976).

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