SOME DIETARY INTERACTIONS OF SUGAR CANE JUICE AND HIGH PROTEIN SUPPLEMENTS

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Sugar cane juice was supplemented by four protein sources in a changeover design using four young bulls of 130 ± 7 kg liveweight at the start of the trial. The protein sources were roughages of *Canavalia ensiformis, Ipomea batata*, wheat bran and *Brachiaria decumbens*. The protein sources and the juice were available to appetite.

Juice intakes were similar between diets and protein intakes of wheat bran and brachiaria grass were higher' than canavalia or Ipomea. Enhanced intakes were reflected in improved rumen conditions in terms of volatile fatty acid molar proportions and increased liquid and indiscriminate marker passage rates from the rumen. Marker passage rates were also compared between rumen and faeces, indicating that polyethylene glycol (liquid phase) clearances were similar (P = .91) and that chromic oxide was unlikely to be reliable (P = .093) as a measure of rumen clearance when measured in the faeces.

Key words: Sugar cane juice, passage rate, *Canavalia ensiformis, Brachiaria decumbens, Ipomea batata*, wheat bran

Sugar cane juice has only recently received attention as a possible source of energy to ruminants. Work carried out by Sanchez and Preston (1980) has demonstrated that growth rates approaching 1 kg/d using only sugar cane juice/urea and a poor quality source of roughage can be obtained. Other work by Gill et al (1981) showed that fresh grass and chopped whole sugar cane can be used as roughage sources to augment juice for growing cattle.

Sugar cane juice is obviously an excellent source of energy for the young ruminant, but to ensure that maximum growth rates are achieved it would seem sensible to feed a protein forage source which can Supply the necessary roughage characteristics and at the same time provide true protein, some of which will by-pass the rumen in the greater amounts required by young cattle. Tropical forage protein sources are not fully proven and frequently only small amounts are available from trial plots. It is therefore useful to get as much. preliminary data as possible from forages so that the efforts of the agronomist can concentrate on materials with suitable characteristics and of use to the animal.

This trial was designed to obtain as much information as possible on the effect of four protein supplements on parameters of rumen digestion. Opportunity was also taken to compare excretion rates of a marker from the rumen, as well as in the faeces. The latter technique avoids the need to use cannulated animals.

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Materials and Methods

Animals, treatments and design: Four young cannulated bulls of 130 ± 7 kg were used in a changeover design experiment with 4 periods of 3 weeks each. In each period the sugar cane juice with 0.8% urea and a protein source were fed ad libitum,

The treatments (protein sources) were confounded with periods and were given in the order: canavalia, sweet potato, wheat bran and brachiaria grass. Restricted availability of the canavalia and sweet potato forage and changes in the maturity of the crops made it inappropriate to use an alternative statistical design.

Procedure: On day 15 of each period and before offering fresh feed, 100 g of Polyethylene glycol 4000 (PEG) and 40 g of Chromic oxide were introduced into the rumen cannula as slurry mixed with water. Samples of strained rumen contents were used for PEG (fresh basis) volatile fatty acids (VFA) and pH measurements, Samples of rumen contents were taken through a 13 mm bore pipe and used to determine chromic oxide (dry basis). The samples were taken at 3, 6, 9, 12, 15 and 24 hr after introduction of the markers. VFA levels and molar proportions were determined by gas liquid chromatography with isovaleric acid as an internal standard in the samples.

Dacron bags containing the different protein sources were concurrently incubated and removed after 6, 12, 24, 36 and 48 hr in the rumen (0rskov et al 1980).

8 hr bulked samples of faeces ending at 48, 56, 64, 72, 80 and 88 hr were sub-sampled for chromic oxide (dry basis) and PEG (fresh basis) determinations.

In rumen and faeces, PEG was determined by the technique of Malawer and Powell (1967) and chromium by acid digestion and reading the transmittance at 375 nm.

Calculations: An analysis of variance was used to compare intake and VFA data.

Individual marker clearance rates were determined by regression using an exponential function to obtain fractional clearance rate (%/hr). Within animal clearance rates, between animals, between markers and between rumen and faeces, were compared by modified 't' test on the two regression lines (Bailey 1976). An analysis of variance of the regressed clearance rates was used to compare forages, and rumen-faeces results were compared by paired 't' test. The pairs were within animals and diets.

Degradabilities of the forages were expressed as time for 50% dry matter (DM) loss (T 1/2) and rate of loss in %/fur obtained by fitting an exponential function. The intercept of the DM axis at time zero was taken as the rapidly soluble fraction.

Results

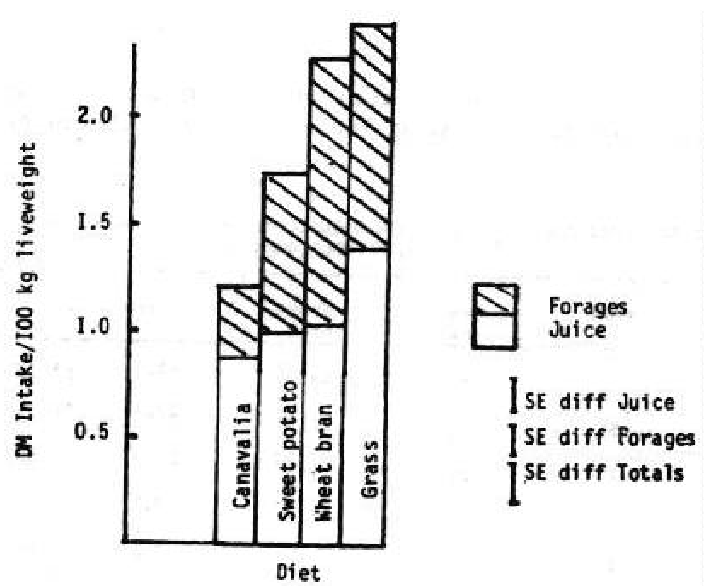
One animal became ill and subsequently died of undetermined causes during the experiment and another had problems with the cannula. Hence intake data are for three animals and rumen data for two animals. Feed intakes (in kg/100 kg body weight/d) are presented in Figure I and Table 1. There were no differences between animals except when forage intakes alone are considered .One animal differed (P <.05) in forage consumption from the other two although there was a tendency for juice intakes between animals to compensate and hence overall DM consumption differed less.

Table 1:
Mean dry matter intakes of sugar cane juice and supplements by 3 young bulls

	Supplements				
	Canavalia forage	Sweet potato forage	Wheat bran	Grass	SE diff.
DM intakes (kg/100 kg body weight					
Total	1.2^{c}	1.7^{b}	2.3^{c}	2.4^{a}	.18
Cane juice	$.8^{a}$	1.0^{a}	1.0^{a}	1.4^{c}	.13
Supplement	$.4^{a,c}$	$.7^{b}$	1.3^{d}	1.0^{a}	.10

Within rows levels of significance are:
a - b $P < .05$
c - d $P < .01$
a - c $P < .001$
b - d $P < .05$

Figure 1:
Mean dry matter intakes of sugar cane juice and supplements by 3 young bulls



Within animals and between forages, the forage intakes were additive to juice intakes, resulting in total intake differences between diets (P < .01) caused by the differences in forage consumption (P < .01). Despite the excellent palatability of sweet potato forage it seems that the low dry matter of the crop prevented intakes reaching those of the drier materials, grass and wheat bran.

The dacron bag degradabilities differed markedly between the supplements (Table 2). The soluble fraction was highest on wheat bran (48%) and least on the grass (effectively 0%). Values for canavalia (5%) and sweet potato (8%) were intermediate. Rate of degradability of the insoluble component was highest for sweet potato forage.

Table 2:

Mean values (± SE) of the degradabilities of four supplements incubated in dacron bags in the rumen of young bulls fed a sugar cane juice diet and the same supplement

	Supplements			
	Canavalia forage	Sweet potato forage	Wheat bran	Grass
Total 1/2 time (hr)[2]	66 ± 36.0	29 ± 7.3	2.8 ± 6.0	82 ± 8.1
Insoluble 1/2 time (hr)[2]	72 ± 39.0	34 ± 7.1	55 ± 3.5	78 ± 12.4
Soluble component (%)	5.2 ± 3.0	8.0 ± 12	48 ± 4	-4 ± 5
Rate of loss (%/hr)	1.2 ± 0.83	2.1 ± .50	1.3 ± .06	0.9 ± .14

[1] Time for 50% dry matter loss from the whole supplement

[2] Time for 50% dry matter loss from the non-soluble fraction of the supplement

The individual VFA levels between diets were examined for the two animals which completed the trial (Table 3). Butyrate differed between diets (P <.05) and levels on

Table 3:

Rumen VFA molar proportions and total VFA concentrations in young bulls fed a sugar cane juice diet supplemented with different protein supplements

	Canavalia	Sweet potato	Wheat bran	Grass	SE diff
Acetate	$45.7^{b,1}$	49.7^{b}	49.7^{b}	62.3^{a}	±3.22
Proprionate	17.8^{b}	16.2^{b}	26.5^{a}	22.7	±2.51
Butyrate	27.7^{c}	27.5^{c}	15.7^{d}	13.5^{d}	±1.88
Valerate	6.2^{a}	5.3^{a}	6.5^{a}	2.2^{b}	±1.06
$C_2:C_5$[2]	4.8	5.2	2.7	3.7	± .86
Total (mM/1)	$64.1^{a,d}$	81.7^{c}	60.8^{d}	$55.6^{b,d}$	±2.58

[1] Within rows levels of significance are a - b P <.05
c - d P <.01

[2] $\frac{C_2 + 2C_4 + C_5}{C_3 + C_5}$

both the canavalia and sweet potato diets were significantly higher than those on either wheat bran or grass ($P <.01$). Proprionate levels on wheat bran were higher than on either the sweet potato ($P <.05$) or canavalia ($P <.05$) diet. Acetate levels were higher ($P <.05$) when grass was fed, compared to any other forage. Differences in $C_2:C_3$ ratios were not significant although the higher C_3 production in the wheat bran ration approached significance over that in the sweet potato diet ($P =.064$)

The marker comparisons for the two animals completing the trial are shown in Table 4. From the rumen, when the regressed clearances are considered, PEG clearance on the grass diet was significantly faster ($P <.01$) than the other three diets. The inverse was true for chromic oxide where clearance on the grass diet was slower than sweet potato or wheat bran ($P <.05$) and canavalia ($P <.01$).

For faeces, PEG flow rates differed between the wheat bran and the sweet potato diets ($P <.05$) but it was not possible to demonstrate differences in clearance rates for the chromic oxide.

A comparison of individual regressions between rumen and faeces clearance rates within the same animal, on the-same diet,did not reveal any significant differences despite high values for r^2 (mean = .91), and when there was a large difference in clearance rate of 17.3%/hr from rumen, compared with 8.5%/hr from faeces (r^2 = .98 and .96 respectively), the level of probability only reached $P = .32$. Further, when individual regressions within animals were considered it was not possible to demonstrate significant differences within diets between the clearance rates of the two markers although the comparisons within faeces approached nearer to significance.

A paired 't' comparison between rumen and faeces and within markers, animals and diets gave probability levels of $P = .91$ for PEG and $P = .09$ for Cr_2O_3 indicating that faeces measurements of rumen clearance is probably acceptable using PEG but that serious doubts exist concerning the use of chromic oxide in this way.

Discussion

Fresh forage of *Canavalia ensiformis* seems to present an intake problem which it may be possible to overcome by drying or ensiling. Wheat bran was consumed well by the three animals for which complete intake data are available. On molasses based diets lack of long fibre has been shown to decrease rumen turnover and predispose cattle to molasses toxicity (Losada et al 1973).

Rowe et al (1979) also reported a dramatic drop in rumen outflow when forage (sweet potato tops) was removed from a molasses based diet. In the present experiment, the forage eaten in smallest quantities (canavalia) was associated with the slowest clearance rate from the rumen (Table 4) and clearance rates were also relatively slow for the most rapidly degradable forage which was sweet potato tops (Table 2). Conversely, the wheat bran, which because of its small particle size would be expected to pass rapidly from the rumen, appeared to stimulate a high liquid clearance rate. The best forage was the grass, in terms of its effect on rumen function and on intake it also had the smallest rumen soluble fraction and the slowest rate of rumen degradation.

The failure to demonstrate differences in passage rates of the markers as between rumen and faeces does not necessarily mean that it is acceptable to use clearance rates from faeces to measure rumen clearance. Grovum and Williams (1973) and Leng (personal communication) have demonstrated that within a

Table 4:

Clearance rates of PEG and chromic oxide in rumen and faeces of young bulls given diets of sugar cane juice and different protein supplements

	Canavalia	Sweet potato forage	Wheat bran	Grass	SE
Clearance rates (%/hr)					
Chromic oxide					
Rumen	6.76[d,1]	5.44[b]	5.54[b]	1.71[a,c]	± .68
Faeces	3.89	3.40	4.35	4.96	± .81
PEG					
Rumen	3.28[d]	5.95[d]	6.89[d]	10.6	±1.67
Faeces	5.93	5.20[a]	10.4[b]	8.45	±1.53
Rumen volume (litres)	20	23	24	19	±3.3
Liquid flow rate (litres/d)	20	32	39	75	± 11

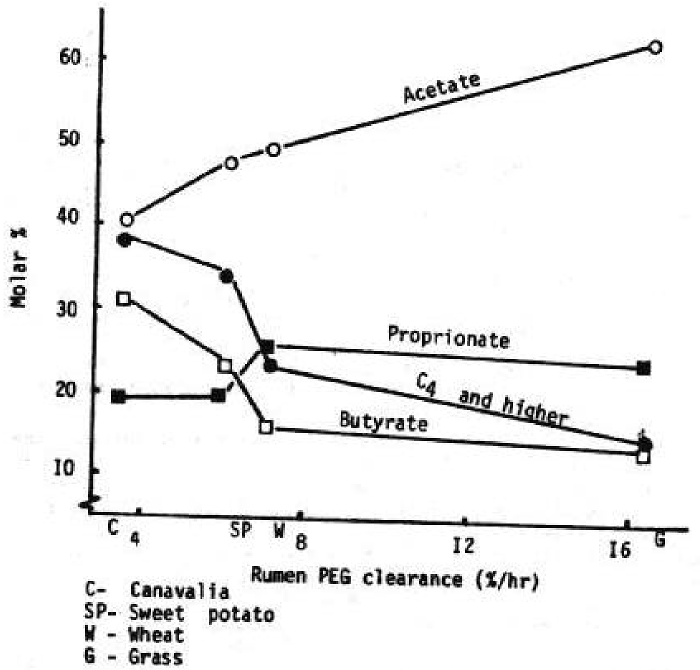
[1] Within rows, levels of significance are a – b $P < .05$
c – d $P < .01$

diet, clearance rate in faeces is similar to that from the rumen. There are, however, few comparative data for rumen and faeces in which different diets have been considered in the same trial , The purpose of this work was to compare forage supplements, their interactions with cane juice and their ability to alter rumen conditions which would have effects on intakes and sites of digestion of both the cane juice and the forage component. Whilst it has been possible to demonstrate dietary differences in PEG and chromic oxide clearances from the rumen, and the PEG in the faeces, the chromic oxide clearances from the whole gut do not appear to change with the diet. The paired 't' comparisons of all values (within diets, animals and markers) demonstrate that rate of clearance from the faeces is an acceptable measure of clearance rate of PEG in the rumen, but that chromic oxide is less suitable for this purpose.

The large differences in rates of liquid clearance from the rumen, particularly between grass and the other supplements, is in contradiction to the results reported by Godoy and Elliott (1981) for molasses based diets in which there were no differences between banana leaves, leucaena and the tops of cassava, sweet potato and sugar cane.

The rumen liquid clearance rate appears to be related to the molar proportions of volatile fatty acids (Figure 2). The most pronounced effect was the reduction in molar proportions of C4, C5 and C6 acids and the increase in acetate with increasing rate of liquid flow . The VFA composition at low clearance rates was very similar to that found on molasses diets when proprionate levels are lower than those of butyrate (Marty and Preston 1970). One possible explanation for the change in VFA fermentation is that protozoa and bacteria with slow growth rates are washed out of the rumen at the high passage rates (Rowe 1978) and that this will produce secondary fermentation of acetate to carbon dioxide and methane, a condition reported to be associated with molasses diets (Rowe et al 1978) and with slow rates of rumen turnover.

Figure 2:
Volatile fatty acid molar proportions and the effect of rumen liquid clearance (measured by PEG)



For ruminant diets based on the ad libitum feeding of a sugar containing feed supplemented with non-protein nitrogen, total feed intake is one of the most reliable indicators of animal performance (Meyreles et al 1979). On this basis the grass supplement was markedly superior to the canavalia or sweet potato forage. The wheat bran was also an effective supplement, however it was eaten in proportionately greater amounts than the forages (Figure 1), and this would have affected favourably the balance of the digestion end products, in comparison with the other treatments, through greater rumen by-pass of the starch and protein in the wheat bran.

Conclusions

Total feed intake and rumen fermentation pattern on a sugar cane juice based diet can be influenced by the supplementary forage source that is fed. Such differences are associated with changes in rumen passage rates, apparent for both liquid (PEG) and indiscriminate markers (chromic oxide).

It does not seem possible to detect liquid clearance rates in the faeces with the same sensitivity as in the rumen,and chromic oxide clearance rates in faeces gave no indication of clearance rate of this marker from the rumen.

For diets based on sugar cane juice, wheat bran and brachiaria grass appear to be more appropriate supplements in terms of effects on intake and rumen function, than either sweet potato or canavalia forages.

For the cane juice diets used in this experiment, the canavalia forage was unsuitable because of low palatability, while the disadvantage of the sweet potato forage appeared to be its too rapid rumen degradability. It may be concluded tentatively, therefore, that for a liquid sugar-based diet a good forage is one which is consumed readily, but is degraded moderately slowly.

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