GLUCOSE METABOLISM IN CATTLE ON SUGAR CANE BASED DIETS: A COMPARISON OF SUPPLEMENTS OF RICE POLISHINGS AND CASSAVA ROOT MEAL[1]

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Glucose entry rates were measured in cattle given sugar cane,urea supplemented with rice polishings or cassava meal. Measurements of glucose metabolism were made 4 hr after feeding for the rice polishings and at 4-7 and 7-10 hr after feeding for the cassava root meal supplement. Glucose entry rates were measured by isotope dilution using (2^3 H) glucose. The major finding wee that glucose entry rates in the cattle were only slightly improved by the cassava root meal supplement whereas they were considerably increased when rice polishings were given. The relationship between the quantity of starch in the supplement and glucose entry rate at 4 and 7 hr after feeding indicated that considerably more glucose was made available to the animals on the rice polishings as compared with the cassava supplement. In cattle given supplements of cassava, the glucose entry rates and all parameters of glucose metabolism were apparently decreased at 7-10 hr as compared to 4-7 hr after feeding. This is a very different pattern to that observed in cattle on rice polishings. An unusual finding was that the space of distribution of glucose in animals supplemented with cassava root meal was higher at 4 hr after feeding than at 7 hr. The major conclusion from this work is that cassava root meal appears to supply only small quantities of extra glucose precursors, indicating extensive fermentation of the starch in the rumen.

Key words: Sugar cane, cattle, glucose entry rate, bypass nutrients, rice polishings, cassava root meal, rumen fermentation.

It has been well documented that cattle fed sugarcane based diets respond to supplementation with rice polishings by increasing feed intake, growth, and feed conversion efficiency (See Preston 1977), It was postulated that part of this response may have been due to increased glucose availability due to starch bypassing the rumen (Leng and Preston 1976).

It has since been shown that glucose entry rates 4 to 7 hr after feeding are directly related to the rice polishings (Ferreiro et al 1978). It has also been demonstrated, with many animals fistulated at the duodenum that considerable quantities of starch appear in the digesta leaving the rumen (Elliott et al 1978a).

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Cassava root is a widely used starch source in tropical countries and it was felt that it could therefore be a useful supplement to substitute for rice polishings when the latter is nor available. However, responses of cattle on sugarcane diets to cassava although positive have been considerably less than those recorded with rice polishings (Preston 1977). Large quantities of cassava have been necessarily fed, suggesting that cassava root may be used quite differently to rice polishings in cattle. Since we appear to have been able to predict glucose absorption from the rice polishings by measuring glucose entry rates we have compared glucose entry rate in animals given different quantities of these two supplements.

Materials and Methods

Experimental animals and diets: F1 Holstein/Zebu bulls about 180 kg live weight were used on the diet containing rice polishings while the cassava experiment was done with Zebu bulls weighing about 240 kg. The animals had been on sugar cane diets for several months prior to the experiment during which time they were tied in individual yokes. All the animals received chopped whole sugar cane supplemented with urea at the level of 3% of the dry matter of the cane. Minerals and vitamins were given as previously described (Preston et al 1976). The supplements were spread on top of the sugar cane at the time of the morning feed. Water was available at all times. There were two animals on each of the levels of rice polishings which were 0, 500 and 1000 g/d; in the cassava experiment there was 1 or 2 animals on each of the levels of 500, 1000, 1500 and 2000 g/d.

Experimental Procedures: The day before an experiment, the animals had a cannula placed in one jugular vein. On the day of the experiment the animals were given the supplement together with sugar cane at about 8:00 a.m. Isotope studies were carried out between 4-7 hr after giving the feed and' for the cassava supplemented group, these were repeated at 7-11 hr postfeeding.

Isotope Injections: (2 - ^{3}H) glucose (200 µc, 2 ma) contained in about 5 ml of solution was injected via the jugular vein cannula over about 1 min. The solution was washed in with a small amount of saline, and blood was taken repeatedly into the syringe and reinjected. Blood samples (7) were taken at 30 min intervals for up to 4 hr post injection. Samples were immediately placed in chilled 15 ml centrifuge tubes containing 1 drop 3000 units/ml heparin. They were cooled in ice and centrifuged at 3000 rv/min for 15 min and the plasma separated and stored at -15° until analysed.

Chemical Methods: Glucose was estimated by the glucose oxidase method of Hugget and Nixon (1957);assay for radioactivity in plasma glucose was estimated by isolating the glucose as the pentaacetate derivative (Jones 1965) and counting in 10 ml toluene containing 1% PPO and 0.01% (w/v) POPOP in a liquid scintillation counter.* Blanks and standards were included with every 10 test samples to determine the background and efficiency of counting. Glucose pentaacetates were prepared from the injection solution in a similar way to that for preparation of samples and the injected amount calculated from the recovery of radioactivity.

Radio Isotopes: (2-^{3}H) labelled glucose was obtained from the Radiochemical Centre, Amersham, UK.

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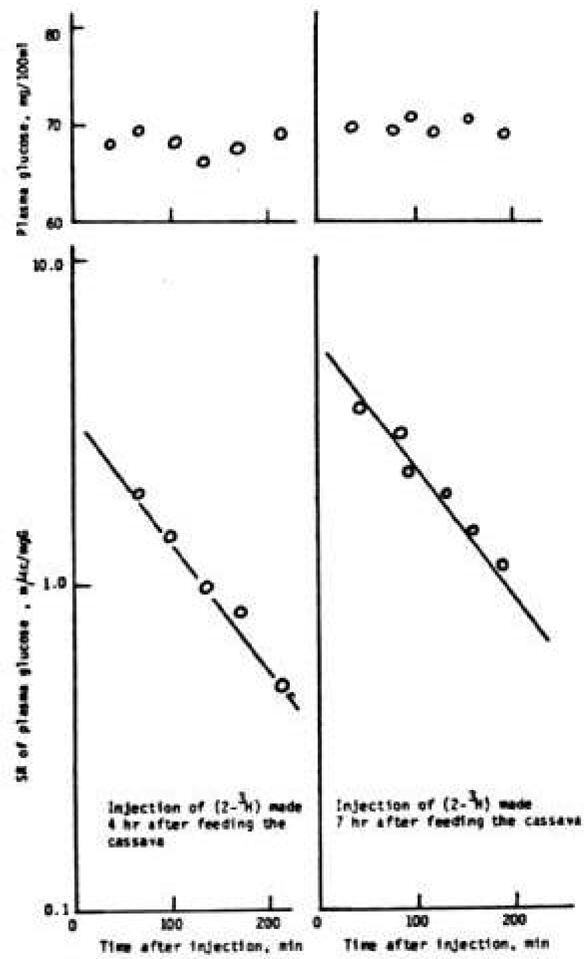
Figure 1:
The concentration of glucose in plasma and the specific radioactivity of plasma glucose following repeated injections of (2- H) glucose in cattle given sugar cane based diets supplemented with 1000 g/d of cassava root meat



Calculations:

The specific radioactivity (SR) of plasma glucose declined as a single exponential function with time (t) (see Fig.1) and was described by

$$SRt = SR_o e^{-mt}$$

where SR_o is the SR of plasma glucose at zero time and assumes instantaneous mixing, and m is the rate constant where

$$m = \frac{1}{t^{1/2} \times 1.44}$$

and $t^{1/2}$ is the time for the SR_o to fall to half.

Table 1:
Glucose metabolism (measured 4-7 hr after feeding) in cattle given sugar cane diets supplemented with rice polishings

Supplement (rice polishings)	Live weight	Plasma glucose conc. (Mg/100ml)	Pool size		t1/2	Glucose entry rate		Space	
			(g)	(mg/kg)	(min)	(mg/min)	($mg/kg^{.75}$ /min)	(litres)	(%live weight)
0	179	81	28	154	80	240	4.9	34	19
0	166	68	30	181	90	232	5.0	44	27
500	161	73	40	247	76	365	8.1	55	34
500	156	71	35	224	95	259	5.9	49	32
1000	204	65	44	218	65	675	8.8	68	33
1000	203	83	42	207	65	446	8.3	51	25

In practice a straight line was fitted by the method of least squares to the log SR with time obtained from 0.5 to 4 hr. Correlation coefficients were between 0.9 -0.99.

Glucose entry rate(GER mg/min),pool size (Po g) and space (S litres) were calculated as follows:

$$P_o = \frac{\text{Injected dose}}{SR_o}$$

$$GER = \frac{P_o}{t^{1/2} \times 1.44}$$

$$S = \frac{P_o}{\text{mean glucose conc}}$$

These calculations assumed little or no recycling of ^3H back to glucose

Results

The specific radioactivity of plasma glucose declined as a single exponential function; a typical result for one animal is shown in figure 1. Plasma glucose concentrations remained fairly constant over the period of sampling. Results for individual animals on the different levels of rice polishings (table 1) and cassava root meal (table 2) are shown in the tables. The results for cassava root meal refer to repeated injections of isotopes made at 4 and 7 hr after feeding. The data for rice polishings refer to a single injection 4 hr after feeding.

Table 2:
Glucose entry rates in cattle given sugar cane diets supplemented with cassava root meal

Cassava supplement	Time after feeding supplement	Live weight	Plasma glucose	t1/2	Pool size		Glucose entry rate		Space	
(G/d)	(hr)	(kg)	(mg/ 100 ml)	(min)	(g)	(mg/kg)	(mg/min)	($mg/kg^{.75}/min$)	(litres)	(% live weight)
500	4	233	72	138	68	292	343	5.7	95	40
1000	4	268	64	94	56	209	406	6.1	86	32
	7		91	74	40	149	378	5.7	44	16
1000	4	209	66	100	57	273	396	7.2	87	41
	7		79	91	47	225	356	6.4	59	28
1500	4	213	67	75	56	263	519	9.3	84	39
	7		90	61	38	169	432	7.7	42	19
2000	4	261	96	96	56	215	403	6.2	88	33
	7		73	73	51	195	483	7.4	54	20

In cattle given the cassava supplement all parameters of glucose metabolism were much lower 7 hr after feeding as compared to 4 hr after feeding. Glucose entry rates(4-7 hr) are plotted against the estimated quantity of starch in the supplements for both the rice polishings and cassava root. meal trials(figure 2),The starch content of rice polishing was assumed to be 40% (Elliott R pers comm) and of cassava root meal 80%. For comparative purposes, the relationship between glucose entry rate and starch supp plied in different levels of rice polishings in a similar experiment carried out in Mexico are also shown (Ferreiro et al 1978).

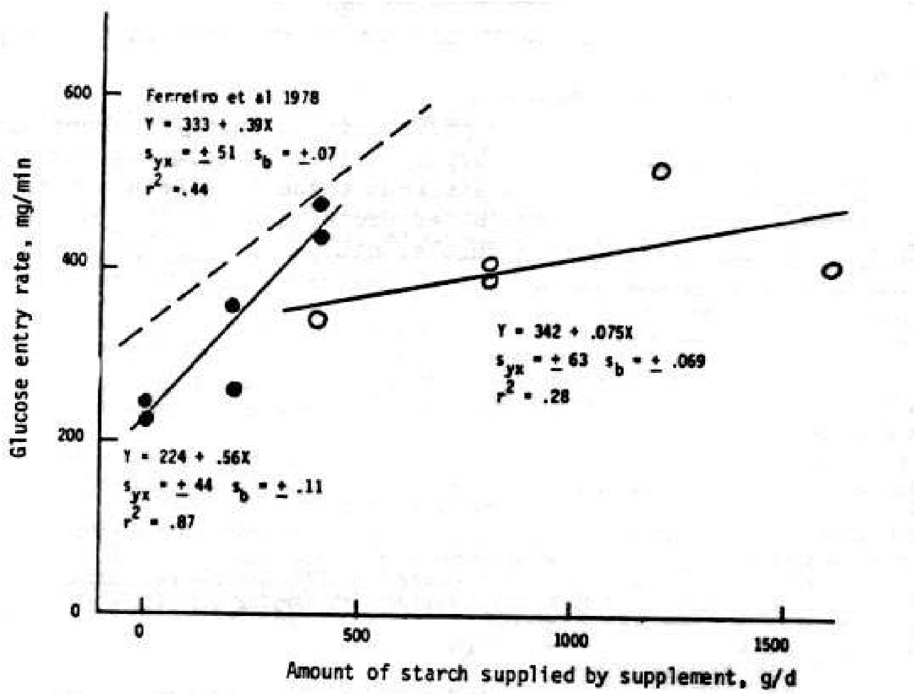
The level of supplementation had no obvious effects on any of the parameters of glucose metabolism other than entry rate. There was a marked increase in glucose entry rate according to the amount of rice polishings that were given (r^2 = .87); in contrast there was only a trend towards increased glucose entry rates with different levels of cassava root meal and the effect was not significant (r^2= .28).

Discussion

The effect of rice polishings on glucose entry rates in this experiment was very similar to that reported for work done in Mexico by Ferreiro et al (1978) (see figure 2).

The striking feature of the results is the marked contrast between the two supplements in relation to their effects on glucose entry rates. It has been established (Elliott et al 1978a) that a considerable amount of starch escapes fermentation when rice polishings are given; this was also indicated by higher glucose entry rates both in the studies referred to here and in Mexico. However, this does not appear to take place when cassava root meal is the sole starch source. The data indicate that prob ably very little cassava starch bypasses the rumen and that the majority is fermented. The trend to increased glucose entry rates with increasing level of cassava root meal probably reflects little more than the overall increase in intake of fermentable organic matter because of the supplementation.

Figure 2:
Relationships between starch supplied by supplement and glucose entry rate in bulls fed sugar cane based diets (◦ cassava supplement, • rice polishings supplement); the data from Ferreiro et al 1978 refers to rice polishings.



The fact that all parameters of glucose metabolism appeared to be much lower in cattle given the cassava root meal 7hr after feeding as compared with 4 hr, indicates the effects of this supplement were short lived unlike the prolonged increase in glucose entry rates in animals given the rice polishings (Ferreiro et al 1978). The larger apparent glucose space at 7 compared with 4 hr after feeding is unusual and suggests that the glucose space in these animals changes, perhaps due to changes in hormone status.

The apparent difference in fermentability between the two starch sources could be due to a number of factors. One of these could be starch structure and the other may relate to the presence of associated nutrients specifically oil since rice polishings contain approximately 13% of lipids, where as cassava root meal has less than 1%. The way in which oil is incorporated in the supplement could also be important. Thus when groundnut oil was included in the diet together with cassava root meal there was no response in animal performance (in this case the oil was simply poured on the top of the feed) (Silvestre et al 1977); however when maize oil was mixed thoroughly with a mixture of fish meal and soybean meal there was a significant improvement in animal performance (Ferreiro et al 1977).

The other factor which differs between the two supplements is the protein in the rice polishings which also appears to escape fermentation (Elliott et al 1978b) and could have a significant effect on glucose entry rate. However the additional amount of glucose that might be produced from the small amount of protein in the rice polishings seems unlikely to account for the very large differences in glucose entry rates in cattle given the two supplements.

The consistent and large effects of rice polishings on animal productivity appear to be due to the availability of bypass nutrients (glucose and protein) and adds; strong support to the thesis that these nutrients are major limitations to growth of cattle on cane based diets, however the influence of the oil in the supplements requires further study.

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