SUPPLEMENTATION OF SUGAR CANE/UREA FOR GROWING CATTLE: LEVELS OF MAIZE GRAIN AND A PROTEIN CONCENTRATE [3]

R Silvestre, N A MacLeod[1] and T R Preston[2]

Centro Dominicano de Investigación Peucaria con Caña de Azúcar
CEAGANA, Santo Domingo R D

Two experiments were carried out to determine the effect on rate of growth and conversion of different levels of a protein supplement, with or without maize grain in basal diets of sugarcane/urea or sugar cane and molasses/urea given in separately feeders. In experiment 1 the levels of a 30% protein concentrate (compounded from soya bean, meat, maize gluten and alfalfa) were 0, 300, 600 and 900 g/d with or without 1000 g/d of ground maize grain. There were two groups of 4 animals on each subtreatment in a 4 x 2 factorial cosign with two replications In experiment 2, the: two principal treatments were: (A) basal diets of sugar cane/urea or sugarcane in one feeder and molasses/urea (10% urea) in another; (B) eight levels of maize in the range 400 to 1800 g/d. There were 3 animals per treatment group and the design was a 2 x 8 factorial with one replication. In experiment 1, during the 84 day trial. There were significant linear responses to added protein (1.79g daily gain/g of supplementary protein) and to added maize (200 g daily gain/kg of maize). In the second trial, the diet containing: molasses supported faster live weight gain (622 vs 489 g/d) but there were no differences in feed conversion. There was a significant response to added maize (202 g/d live weight gain/kg maize) on the sugar cane/urea diet but not on the diet containing molasses, where the response was zero. There were no differences in molar proportions of the volatile fatty acids between any of the diet or supplement treatments in both experiments the range being: C_2 50 to 60; C_3 25 to 32; C_4 12 to 20. The holotrich protozoa biomass and entodinea count also did not differ between treatments, the range of values being of the order l to 3% for biomass in rumen fluid and.01 to.05 $XI0^5$/ml of entodinea. It is concluded that the results support the hypothesis that protected protein and glucose precursors are limiting factors to animal performance in diets based on sugar cane.

Key words: sugar cane, protected protein, glucose precursors, cattle

---

[3] This work was supported in part by funds provided by the Organization of American States through the project Fondo Mar del Plata

[1] On secondment from Rowett Research Institute, Aberdeen, Scotland

[2] Scientifc Adviser to CEAGANA

In the utilization of sugar cane for cattle feeding, it is considered (see Leng and Preston 1976) that the factors limiting animal performance are: (1) ammonia for the rumen microorganisms; (2) "protected" protein to provide a balanced source of essential amino acids to supplement the microbial protein produced in the rumen; and (3) glucose precursors.

Urea has invariably been the source of ammonia, and a number of methods have been used to incorporate it in the ration: e.g. as solutions in final molasses, or in water, which are then mixed with the sugar cane; or dissolved in molasses (usually at the level of 100 g urea/kg) for feeding free choice in one feeder while the sugar cane is given in another. From the management point of view there are many advantages in this latter system; there is also less risk of urea losses when this method is used.

The objectives of the two experiments reported here were to measure performance of Zebu steers fed a basal ration of chopped whole sugar cane using (a) two methods of giving the urea, and (b) various levels of glucose precursors (as maize grain) and protected protein.

Materials and Methods

Treatments and Design: In experiment 1, the treatments in a 4 x 2 factorial design with 2 replications consisted of: (A) a protein supplement (30% protein) at levels of 0, 300, 600 and 900 g/d; and (B) o and 1000 g/d ground maize. In the second experiment, the treatments in a 8 x 2 factorial design with one replication were (C) two systems of giving urea: (C_1) as an aqueous solution mixed with the chopped sugar cane: and (C_2) as a concentrated solution in final molasses given separately from the sugar cane. The other principal treatment(D) was levels of maize grain of 400, 600, 800, 1000, 1200, 1400, 1600 and 1800 g/d.

Animals: Zebu steers of between 1 and 1.5 years of age were used. The mean average weights were 163 and 197 kg for experiments 1 and 2 respectively. In experiment 1 they were housed in groups of 4 and in experiment 2 in groups of 3 in slatted floor 3 X 3m pens.

Diets: The basal diet was chopped whole sugar cane (processed with a maize forage harvester (Gehl 600) In experiment 1, the aqueous urea solution 200 g urea/litre) was mixed with the chopped cane at the rate of 50 ml of solution/kg of cane using a portable feed mixer (Gehl 180). The same procedure was used for treatment C_1 in experiment 2; treatment C_2 in this experiment had free access to liquid urea/molasses (100 g urea, 100 g water and 800 g final molasses) given in a feeder separately from chopped whole sugar cane which was also provided ad libitum.

The appropriate quantities of protein concentrate and ground maize, together with the minerals, were given on top of the sugar cane feed when this was put in the trough in the morning. The protein concentrate was purchased from a commercial company and had been formulated as a protein balancer for pigs. It contained soya bean meal, meat

meal, maize gluten, dehydrated alfalfa, vitamins and minerals, and presumably in proportions calculated to give a balanced supply of essential amino acids.

Measurements: : The animals were weighed at 15 day intervals: feed intake was recorded daily. Periodic analyses were made of the dry matter in the cane and the Brix of the juice.

At the end of the experiment, samples of rumen fluid were taken by stomach tube for determination of volatile fatty acid proportions (Gonzalez and MacLeod 1976) and protozoa biomass (Leng et al 1976).

Results

Animal performance: Mean values for changes in live weight and feed intake are set out in tables 1 and 2 for the individual treatments in each of the two experiments. The relationships between the treatment variables and measurements of animal performance are given in figures 1 and 2.

Table 1:
Mean values for live weight changes and feed intake in experiment 1 (eight animals per treatment per 84 days)

	Without maize				With maize			
Protein supplement, g/d	0	300	600	900	0	300	600	900
Live weight kg								
Initial	159	166	170	166	164	165	159	160
Final	167	189	197	208	182	203	207	215
Daily gain	.142	.333	.412	.567	.267	.544	.657	.604
Feed intake, kg/d								
Sugar cane	10.0	10.3	10.4	10.3	9.50	9.66	9.61	9.74
Urea	. 11	.11	.11	.11	.10	.10	.10	.10
Total DM	2.81	3.16	3.54	3.74	3.58	3.89	4.17	4.48
Consumption index[1]	1.73	1.79	1.93	1.99	2.07	2.12	2.30	2.40
Conversion[2]	17.04	9.39	8.32	7.29	13.15	7.94	6.87	6.41

[1] DM intake/100 kg LW
[2] DM intake /gain in LW

Table 2:
Mean values for live weight change curd feed intake in experiment 2 (3 animals per treatment group for 84 days)

	Level of ground maize kg/d							
	.4	.6	.8	1.0	1.2	1.4	1.6	l.8
				Sugar cane/urea				
Live weight, kg								
Initial	161	182	194	182	208	230	200	197
Final	197	216	235	232	249	266	259	255
Daily gain	.43	.40	.49	.60	.49	.43	.70	.69
Feed intake, kg/d								
Sugar cane	12	13	l3	12.5	12.6	12.6	12.5	12
Molasses	-	-	-	-	-	-	-	-
Urea	.12	.13	.13	.13	.13	.13	.13	.12
Total DM	4.15	4.60	4.77	4.80	5.0	5.17	5.31	5.31
Consumption index	2.32	2.31	2.23	2.32	2.18	2.08	2.31	2.36
Feed conversion	9.65	11.50	9.73	8.0	10.2	12.0	7.59	7.74
				Sugar cane + molasses/urea				
Live weight, kg								
Initial	188	193	212	203	201	197	203	213
Final	230	250	264	247	255	235	235	277
Daily gain	500	580	620	520	640	450	430	750
Feed intake, kg/d								
Sugar cane	10.75	11.0	11	10.3	11	10.6	10.6	11
Molasses	1.27	1.44	1.50	1.06	1.77	1.11	1.13	1.13
Urea	0.11	.16	.17	.12	.20	.12	.13	.13
Total DM	4.94	5.33	4.94	5.33	5.52	5.16	5.82	6.08
Consumption index[1]	2.36	2.40	2.32	2.29	2.63	2.60	2.63	2.48
Feed conversion[2]	9.88	7.84	8.90	9.92	9.59	12.49	13.5	8.0

[1] Kg DM/100 kg LW
[2] kg DM/kg gain in LW

Figure 1 :
Relation between animal performance and quantity of protein concentrate on sugar cane/urea diets with kg maize daily (●) or none(○)

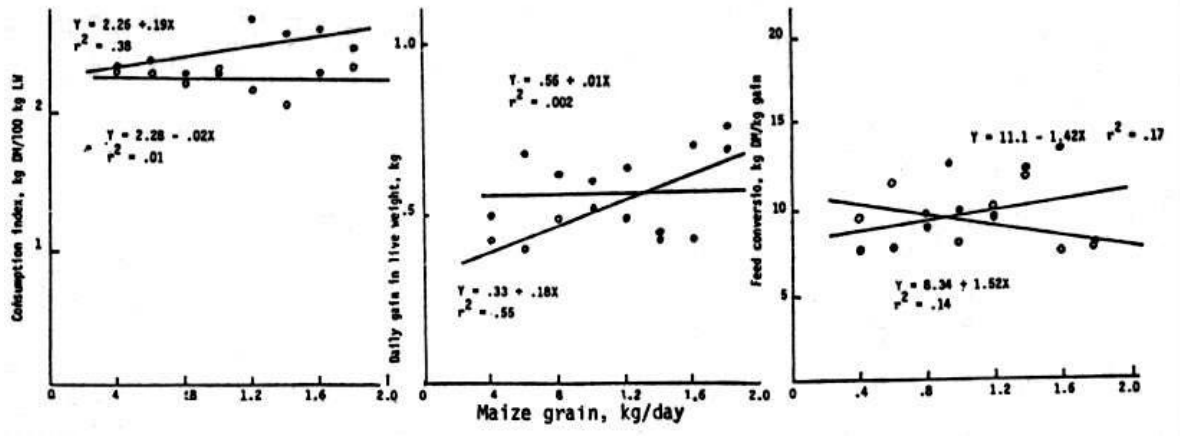
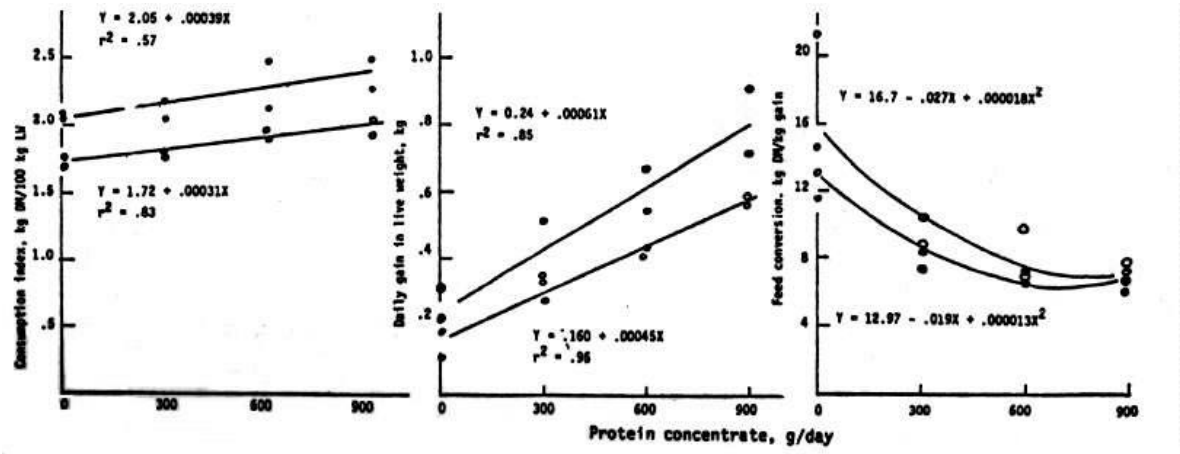


Figure 2:
Relation between animal performance and level of supplementary maize grain on sugar cane/urea (○) and sugar cane plus molasses/urea (•)



In experiment 1 there was a linear response in rate of live weight gain according to the amount of protein given. Voluntary feed intake response appeared to be curvilinear, with the maximum consumption being reached at the level of 180 g daily of true protein. Feed conversion response was also curvilinear with the greatest improvement coinciding with the addition of the first 90 g of true protein, the response thereafter declining according to the law of diminishing returns. Addition of maize increased significantly all the performance parameters, the overall effect on live weight gain being almost 60%. There were no apparent interactions between the effects of maize and protein.

The nature of the effects of the treatments on animal performance in experiment 2 were unexpected. There was a significant increase in live weight gain with increasing levels of maize for the sugar cane/ urea diet, but no effect for the ration of sugar cane and molasses/urea given in separate feeders. There were significant differences between the two diets for voluntary intake and live weight gain which were greater for the sugar cane and molasses/urea programme compared with sugar cane/urea. There were, however, no differences in feed conversion.

Rumen fermentation: The parameters of rumen fermentation are summarised in tables 3 and 4 for the two experiments. In contrast with the marked treatment effect on live weight gain there were apparently no differences between treatments in proportion of volatile fatty acids or the population of protozoa. The range of values were almost identical as between the two trials, irrespective of treatment.

Discussion

The highly significant linear response to additional true protein in the first experiment is in agreement with findings reported by Preston et al (1976) and Lopez et al (1976) when rice polishings were added to sugar cane diets. In these experiments, responses were linear to a total daily intake equivalent to 150 g true protein from the rice by-product. In the present experiment however, response was linear as far as the equivalent of 270 g/day of true protein. The overall rates of gain reported by Preston et al (1976) and Lopez et al (1976) per unit of supplementary protein were approximately 6 g live weight gain/g supplementary protein, compared with approximately 1.7 g gain/g additional protein in the present experiment. This difference in response may reflect the poorer genetic merit of the cattle used here. It is also probable that the biological value of the protein in rice polishings was superior to that in the commercial protein concentrate used in this experiment.

The significant response to supplementary maize at all levels of protein in experiment 1 would appear to confirm the suggestion of Leng and Preston (1976) that the availability of glucose precursors can limit animal performance on sugar cane diets. It should also be pointed out that the protein concentrate used also contained some maize and it is possible that this also contributed to the apparent response to protein. In other trials with almost pure proteins of animal origin there was no response to

increasing level: e.g. with meat meal (Preston and Bonaspetti 1974) and fish meal (Preston 1974). This suggests that there are nutrients (or precursors of nutrients) in rice polishings and maize (both of vegetable origin) which are not present in protein sources of animal origin. The most logical factor would appear to be starch acting as a precursor of glucose. If this was confirmed then it implies that glucose production from starch hydrolysis in the intestine is more efficient/effective than gluconeogenesis via degradation of protein.

The important observations arising from the results of experiment 2 would seem to be: (1) the response to maize on the diet of sugar cane/urea; (2) the lack of response to maize on the diet of sugar cane and molasses/ urea, and (3) the significantly better feed intake and live weight gains on the sugar cane and molasses/urea diet compared with sugar cane/urea The only apparently explanation for these effects is that the molasses and maize were providing some nutrients not present in sugar cane.

On evidence available elsewhere (Ferreiro et al 1976) it is possible that this nutrient was sulphur. Sulphur is in relatively low concentration in sugar cane (less than 0.3% in DM according to Anon 1974), but higher in final molasses (0.46%) (NRC 1972). It was shown by Ferreiro et al (1976) that addition of as little as 1 g ammonium sulphate per kg of fresh cane improved significantly daily gain on a ration composed otherwise of only sugar cane and urea. Similar findings were reported by Siebert and Hunter (1975).

The response to maize on the sugar cane/urea diet cannot be explained in terms of a sulphur response since it is poorer in this element (0.03% in DM) than sugar cane. It seems equally implausible to suggest that there are deficiencies of glucose precursors in a sugar cane/urea diet (that diet gave the same response to maize in both experiments: 202 g of live weight gain/kg maize in experiment 1 and 206 g/kg maize in experiment 2) but not on a sugar cane diet which contains molasses.

Table 3:
Mean values for rumen FVA and protozoa determinations in experiment 1

	Without maize				With maize 1000 g/d			
Protein supplement. g/d	0	300	600	900	0	300	600	900
VFA. molar %								
Acetic	49.6	52.5	57.4	56.8	55.1	53.5	56.3	49.5
Propionic	33.6	31.6	27.9	28.4	25.2	27.5	30.5	38.2
Butyric	16.8	15.9	14.7	14.8	18.8	19.0	18.2	16.0
Entodinea, X 10^{-5} /ml	.18	.14	.09	.11	.37	.26	.09	.13
Holotrichs, PCV % rumen fluid	.21	1.56	1.29	1.12	2.38	1.41	2.11	1.49

The opposite would be expected since the rumen fermentation pattern on molasses/urea based diets shows lower molar proportions of propionic acid and higher proportions of butyric acid (i.e. is less glucogenic) than on cane/urea (Ravelo et al 1976).

The general lack of effect of any of the dietary treatments on the pattern of rumen fermentation is in agreement with the conclusions of Minor et al (1976), that this phase of digestion on sugar diets is extremely stable and not influenced by the feeding of starch or protein supplements.

This implies that if maize is acting as a source of glucose precursors,then the effect is being manifested by passage of intact starch through the rumen to the intestine for direct hydrolysis there to glucose, rather than by the production of propionic acid in the rumen. This is compatible with the findings of Armstrong and Beever (1969) that maize grain is comparatively resistant to rumen fermentation and that a considerable proportion does pass through to the intestine.

Another interesting finding in experiment 2 was that despite better live weight gain on the treatment with sugar cane and molasses/urea, feed conversion efficiency remained the same. This suggests that the digestible organic matter in this feed is utilized less efficiently than the organic matter in sugar cane alone. A similar conclusion was arrived at by Alvarez et al (1976), on the basis of findings that while live weight gain was similar on sugar cane/urea and sugar cane plus molasses/urea diets, feed conversion was better on the former.

These results can also be interpreted as reflecting a lower glucogenic status on the molasses/diet, since feed conversion efficiency on diets with the same digestibility is a direct function of the glucogenic ratio (i.e. the proportion of the digestible end products that can be used to form glucose) (0rskov 1975).

Conclusions

The results are compatible with the hypothesis that both protected protein of high biological value, and glucose precursors, limit growth rate on sugar cane based diets. However, the order of importance, and economic value, to be attached to these two sources of nutrients, and the possibility of interactions between these have still to be clarified.

References

Ferreiro H M, Sutherland T M & Preston T R 1976 Some dietary limitations on sugar cane based diets Trop Anim Prod 1:

De Gonzalez L & MacLeod N A 1976 Spontaneous fermentation of sugar cane Trop Anim Prod 1: 80-85

Leng R A & Preston T R 1976 Sugar cane for cattle production: present constrains perspectives and research priorities Trop Anim Prod 1:1:22

Leng R A, Valdez R E, De Gonzalez E & Minor S, 1976 A method for assessing protozoal biomas in rumen fluid Trop Anim Prod 1:42

Lopez J M, Preston T R, Sutherland T M & Wilson A 1976 Rice polishings as supplement in sugar cane diets; effect of level or rice polishings in wet and dry season conditions Trop Anim Prod 1:164-171

0rskov E R 1975 Manipulation of rumen fermentation for maximum feed utilization Wld REv Nutr Diet (Ed G HBourne) Karger:Basle

NRC 1972 World Atlas of Feeds Nat Academy Sciences: Washington, DC

Preston T R 1974 Beef and milk production from sugar cane report to Ministry of Agriculture, Natural Resources and Environment, Mauritius (FAO, Rome)

Preston T R & Bonaspetti E 1975 E1 uso de la harina de came y Grea como suplementos en una racion de engorde de cane de Azúcar integral picada Resumenes de trabajos presentados en la Primera Reunion Anual del CIEG Informe Anual 1974 CIEG, Chetumal, Mexico

Ravelo G, MacLeod N A 6 Preston T R 1976 The pattern of rumen fermentation in bulls fed chopped whole sugar cane and sugar cane tops plus molasses, in each case with and without urea Trop Anim Prod 1976 1:242 Abstr

Siebert B D & Hunter R A 1975 The utilization of sugar cane by beef cattle supplemented with animal protein, plant protein or nonprotein nitrogen and sulphur In preparation

Received 3 June 1976