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ACID-BASE BALANCE IN YOUNG BULLS FED ENSILED SISAL BAGASSÉ (*Agave fourcroydes*)[1]

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Sixteen young zebu bulls with an initial mean live weight of 202 (± 7) kg were fed on a basal diet of ensiled bagasse to study the effect on animal performance and acid-base balance of neutralisation of the bagasse and the supplementation with elephant grass (*Pennisetum purpuram*). In the 2 x 2 factorial design the levels were with and without neutralisation with sodium hydroxide (NaOH) and with and without a supplement of elephant grass at 20% of total dry matter intake (DMI). An additional control group of 3 animals of the same type and weight was fed elephant grass *ad libitum*. All diets contained minerals and urea to give a total nitrogen intake equal to that of the control group. Live weight changes, voluntary DMI, blood (pH, pCO_2, HCO_3 and tCO_2) and urinary parameters (pH and net acid-base, NAB) were measured periodically during the experimental period of 36 days.

All animals consuming bagasse lost weight, the loss being significantly greater ($P < 0.01$) in animals which were not supplemented with grass. The control animals gained weight (100 g/d), the weight change being significantly different from that of the animals fed the sisal bagasse treatments.

After thirty days some blood parameters of animals supplemented with grass were significantly lower, pH ($P < 0.01$), tCO_2 ($P < 0.05$), HCO_3^- ($P < 0.05$) than in the non-supplemented groups. Neutralisation had a similar effect after 15 days consuming the sisal diets. Neutralisation also significantly (P 0.01) increased NAB in urine after 29 days. A significant interaction ($P < 0.01$) with respect to urine pH was observed between supplementation and neutralisation of the bagasse.

It was concluded that an alteration in acid-base balance is not the major cause of low intake and hence poor animal performance with diets based on sisal bagasse.

Key Words: Sisal bagasse, acid-base balance, animal performance

The by-products produced from the extraction of the fibre from the sisal plant are bagasse and pulp. Large quantities of these by-products are prodced in the state of Yucatán throughout the year, which provides a potential source of animal feed.

Both sisal bagasse and pulp have been widely studied as animal feeds. When supplemented with urea only a low boluntary DMI and poor animal performance is evident. The use of protein, energy and forage supplements has also been studied (Ferreiro et al 1978; Godoy et al 1979; Priego et al 1979; Dixon et al 1979; Gutiérrez et al 1981). The usual response has been an increased DMI due to the supplement and not an increase in the voluntary consumption of the bagasse or pulp. In terms of animal production the response to the different supplements has been variable, which may indicate the energy from the bagasse is sometimes used efficiently even though the efficiency of utilization of the energy is usually poor (Harrison 1984).

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A metabolic acidosis, in which a blood pH of 7.285, haemoconcentration, high lactic acid levels in blood and low urine pH were found (Naseeven 1981), may be a possible explanation for the apparent inefficiency of the use of energy from sisal based diets (Harrison 1984). It is important to point out that the sisal by-products, both fresh and ensiled, have a very low pH due to their high content of organic acids (Harrison 1984). However, an acidosis at the level of the rumen has not been found.

The present study was carried out to relate the poor animal performance of animals consuming ensiled sisal bagasse with acid-base balance (blood and urinary parameters).

Materials and Methods

Animals: Sixteen young zebu bulls, 10-12 months of age with a mean initial live weight of 202 ± 7 kg were used. They were treated against internal and external parasites.

The animals were housed in groups of 4 in 5m x 4m pens with cement floors and artificial shade. Water was available at all times. Three additional animals of the same type and weight were used as a control group.

Experimental design: The experimental design was a 2 x 2 factorial in which the levels were ensiled sisal bagasse with and without neutralisation with sodium hydroxide and with and without a supplement of elephant grass at 20% of total DMI. The additional group of 3 animals was fed elephant grass *ad libitum* and acted as a positive control. All diets contained minerals (100 g/animal of 1:1 mixture of Rumisal - commercial mix - and rock phosphate) and urea to give a total nitrogen intake equal to that of the control group.

Procedure: The bagasse and the grass were offered separately each day. A watering can was used to pour a 10% solution of NaOH over the bagasse to pH 7. Urea was applied with the NaOH and an equal volume of water was added to the other treatments. The minerals were sprinkled over the feed.

Measurement: During an initial 15 day period all groups were fed elephant grass ad libitum and the animals were handled daily to minimize atress during subsequent sampling. At the end of this period samples of blood and urine were taken (Day 0). The experimental diets were then given (Day 1) and the animals were sampled for urine and blood on days 6, 14 and 29 and 7, 15 and 30, respectively.

Urine samples were collected directly from the penis in plastic cups (50 ml). Blood was obtained from the jugular vein using heparinized syringes, which were placed immediately in cold water until their analysis. Voluntary DMI was recorded daily.

The animals were weighed on days 0, 21 and 36 after fasting for 18 h.

Urine pH was determined immediately after collection using a Corning 7 pH meter. Net acid-base in urine was determined by the method of Bartko et al (1979). Analysis of blood pH and pCO_2 was carried out using a Radiometer Blood Gas Analyser B A3, Copenhagen, Bicarbonate (HCO_3^-) and total carbon dioxide (tCO_2) were calculated from the measured pH and pCO_2.

The results obtained were analysed by analysis of variance.

Results

In Table 1 the content of DM and crude protein of the feedstuffs and the pH of the bagasse used in this study are shown. The treatment of the bagasse with NaOH increased the pH almost to the point of neutrality.

Table 1:

pH and the content of dry matter (DM) and crude protein (CP) in sisal bagasse and elephant grass.

	Bagasse	Bagasse + NaOH	Elephant Grass
DM* (%)	20.2	-	19.8
CP** (% of DM)	4.3	-	7.3
pH**	4.16	6.41	-

* Mean of 14 determinations
** Mean of 3 determinations

The four groups of animals consuming bagasse all lost weight (Table 2). However the loss for the groups consuming grass were significantly smaller ($P < 0.01$) than in the non-supplemented groups.

Table 2:

Voluntary intake and live weight changes of animals fed diets based on sisal bagasse, without treatment, neutralised with NaOH and supplemented with grass (20% DMI)

Basal Diet	Ensiled Bagasse				Elephant Grass	SED
	-	NaOH	Pasto	Pasto + NaOH		
Dry Matter intake/animal*						
Bagasse (kg/day)	1.12	1.02	1.31	1.15	-	
Grass (kg/day)	-	-	0.34	0.35	2.21	-
Total DMI* (kg/day)	1.12	1.02	1.65	1.50	2.21	-
Mean live weight (kg) initial	216.5	206.2	204.2	196.0	190.3	-
Final	200.0	192.7	195.2	192.0	197.0	-
Live weight change* (kg/dy)	-0.188_a	-0.196_a	-0.100_b	-0.062_b	$+0.102_c$	0.0563

Means with different subscripts are significantly different ($P < 0.01$)
* Per 100 kg live weight

Neutralisation of the bagasse had no significant effect on live weight changes. The control group, which consumed grass alone, produced a poor live weight gain (102 g/d) which was significantly different ($P < 0.01$)from the losses in the groups consuming sisal bagasse.

The DMI of bagasse and total DMI were increased by 17% and 13%(bagasse) and 47% and 32% (total) in the animlas given the grass supplement for bagasse and neutralised bagasse respectively.

Neutralisation decreased the dry matter intake of bagasse by 9% (bagasse) and 12% (bagasse plus grass) (Table 2).

It is shown in Table 3 that net acid-base values in urine are significantly higher ($P < 0.01$) in animals offered neutralised bagasse. It is also evident that neutralisation prevents the fall in urine pH which is apparent when the animals begin to eat gabasse. A significant interaction ($P < 0.01$) was found between supplementation and neutralisation of the bagasse with respect to urine pH.

Table 3:

The effect of supplementation with grass and neutralisation of sisal bagasse on pH and NAB in urine.

Basal diet		Ensiled bagasse				Elephant grass	SED
			NaOH	Grass	Grass +NaOH		
Day 0**	pH	8.6	8.5	8.5	8.6	8.5	0.13
	NAB*	+149	+133	+120	+174	+183	32.9
Day 6	pH	7.4	8.3	7.8	8.3	8.3	0.07
	NAB	+4	+114	+7	+82	+85	20.6
Day 16	pH	7.5	8.2	7.9	8.4	8.2	0.13
	NAB	+7	+98	+23	+141	+86	23.9
Day 29	pH	7.4	8.4	7.9	8.4	8.1	0.16
	NAB	+10	+108	+33	+128	+81	

* meq/L

** All animals consuming elephant grass *ad libitum*

Of the blood parameters shown in Table 4 pH ($P < 0.05$), HCO_3^- ($P < 0.01$) and tCO_2 ($P < 0.01$) were significantly higher in animals consuming neutralised bagasse without supplement had a significantly higher blood pH.

Throughout the experiment no differences between treatments were observed with respect to pCO_2. After 7 days consuming the diets no differences between treatments were observed for any of the blood parameters measured.

Table 4:

Effect of supplementation with grass and neutralisation of henequén bagasse on pH, pCO_2, HCO_3^- and tCO_2 in blood.

Basal diet		Ensiled Bagasse				Elephant grass	SED
		–	NaOH	Grass	NaOH + Grass		
Day 0***	pH	7.425	7.423	7.427	7.445	7.450	0.0236
	HCO_3^-*	25.77	23.95	24.08	24.16	26.52	1.303
	tCO_2**	27.02	25.12	25.29	25.28	27.74	1.355
	pCO_2	40.6	38.0	37.8	36.5	39.6	26.63
Day 7	pH	7,417	7,432	7.421	7,450	7.424	0.0247
	HCO_3^-	25,19	29,54	25.44	26.53	24.64	2.081
	tCO_2	26,43	30.92	26.69	27.74	25,77	2.163
	pCO_2	40.4	45,7	40.5	39,7	37.0	3.35
Day 15	pH	7,424	7.471	7,422	7,452	7.429	0,0222
	HCO_3^-	25,73	31,48	25,90	28.52	28,08	1.425
	tCO_2	26,98	32.85	27.16	29,82	29.43	1.470
	pCO_2	40,8	44.6	41.0	42,4	43.8	2.44
Day 30	pH	7,477	7.513	7,462	7,452	7.450	0.0188
	HCO_3^-	31,5	32,5	28,0	28.0	28.3	2.19
	tCO_2	33,0	33,5	28,0	29.0	29.5	2.27
	pCO_2	40,7	42.4	40.1	39.3	40.3	2.42

* mmol/L
** mm Hg
*** All animals consumed elephant grass *ad libitum*

Discussion

The results obtained in this study support the theory that one of the principal factors limiting animal performance with diets based on ensiled sisal bagasse is a low voluntary DMI. The intakes observed (Table 2) were similar to those reported by Priego et al (1979) for pulp (1.29 kg MS/100kg live weight) and Godoy et al (1979) (1.19 kg MS/100 kg live weight) for bagasse.

Interpretation of the acid-base balance parameters measured in this trial is difficult as no normal ranges have been published for the breed of animal used, or the environmental conditions in which the experiment was conducted. Considering the values for blood pH in the animals offered bagasse alone, no acidosis is evident. On the contrary, the pH tended to increase during the period of the experiment, which disagrees with the results of Naseeven (1981) who found a severe acidosis under very similar conditions.

Changes in blood pH alone, however, do not permit diagnosis of the nature or cause of an acid-base imbalance. From blood pH and pCO_2 it is possible to calculate the concentrations of bicarbonate and carbonic acid, the relation between which must be maintained close to 20:1 to prevent changes in blood pH. For animals in the groups offered bagasse alone and neutralised bagasse on day 30 this relation is 25:1 which together with the blood pH and pCO_2 values indicate a mild metabolic alkalosis (Tasker 1980). No obvious imbalance was observed for other treatments or days of sampling.

The alkalosis in the group consuming neutralised bagasse is not thought be due to ingestion of alkali since NaOH addition only increased the pH of the feed to 6.4.

The values of pH and NAB in urine of the animals consuming bagasse alone and bagasse plus grass show, according to the classification of Bartko et al (1979), a compensated metabolic acidosis. These results are similar to those obtained by Naseeven (1981) but contradict the values discussed above for blood aprameters in the present study.

It is not possible to define categorically the nature of the acid-base disturbance in the animlas consuming ensiled sisal bagasse since the values observed for blood and urinaty factors appear to be contradictory. A similar phenomenon, however, was observed by Rodríguez et al (1983) in sheep fed ensiled sisal pulp. It seems unlikely that the high blood pH could result from an excessive respiratory compensation for a metabolic acidosis because pCO2 values remained normal (40 mmHg) throughout the study.

Conclusion

It would be difficult to conclude from this work that poor animal performance in animals fed sisal bagasse is due to an alteration in acid-base balance. Performance was poor in group 4 (Neutralised bagasse supplemented with grass) in which no imbalance of any kind was observed. However, evidence for an imbalance is presented, the nature of which cannot at present be defined.

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