

ANIMAL PERFORMANCE AND PHYSIOLOGICAL DISTURBANCES IN SHEEP FED DIETS BASED
ON ENSILED SISAL PULP (*AGAVE FOURCROYDES*)

II. THE EFFECT OF FORAGE SOURCE AND REMOVAL OF SHORT FIBRES

A Rodríguez, J A Riley¹ and W Thorpe¹

Facultad de Medicina Veterinaria y Zootecnia
Universidad de Yucatán
Apartado Postal 116-D
Mérida, Yucatán
México

A 2 x 2 x 2 factorial experiment was carried out to study the effect two forage supplements and the removal of short fibres from a basal diet of sisal pulp on the production and acid-base balance of tropical sheep. The factors compared were breed; Pelibuey and Black Belly, forage source; ramón (*Brosimum alicastrum*) and african star grass (*Cynodon plectostachyus*), and the presence or absence of short fibres in the sisal pulp. Twenty four male lambs, 12 of each breed, with a mean initial live weight of 18 ± 2 kg, were housed in individual pens and fed ensiled sisal pulp ad libitum. All animals received supplements of soya bean meal and minerals. The diets were made iso-nitrogenous (15% CP) by the addition of urea. The experiment lasted 70 days.

Four Pelibuey sheep, of approximately the same age and live weight, were housed in a separate pen and fed african star grass and ramón. These animals formed a control group for the physiological parameters measured.

Voluntary intake of the pulp was not significantly affected ($P > 0.05$) by any of the principle factors, but a significant interaction ($P < 0.05$) between breed and forage source was observed. Pelibuey sheep ate more pulp with the star grass supplement than with ramon (2.89 vs 2.69% of liveweight; LW), with Black Belly sheep the reverse was true (2.71 vs 2.84% LW, respectively). No significant factor effects or interactions ($P > 0.05$) were found for live weight gain. However, gains tended to be better ($P < 0.1$) when ramón was offered than with star grass (81 vs 69 g/day, respectively).

Values of pH and net acid-base in the urine of all animals receiving sisal pulp were very much lower than those measured in the animals of the control group. On the other hand, pH, pCO_2 and the ratio bicarbonate:carbonic acid in blood were maintained close to or slightly above values measured in the control group. Possible causes of this apparent contradiction between acid-base status determined from urine parameters and that determined from blood parameters are discussed.

Key Words: Sheep, sisal pulp, supplementation, growth, acid-base balance.

In a previous study, Rodríguez et al (1984) obtained acceptable live weight gains in sheep fed ensiled sisal pulp (*Agave fourcroydes*) with supplements of soya bean meal, ramón (*Brosimum alicastrum*) and minerals. This type of supplementation, however, is expensive and the forage did not produce the increase in the voluntary intake of the pulp shown in other studies (Gutiérrez et al, 1981; see Rodríguez et al, 1984).

In the sisal processing plant the long fibres are removed from the leaves but a quantity of short fibres remain in the by product bagasse. Some of these are sometimes removed in an additional process which gives the

¹Technical Cooperation Officer, Overseas Development Administration, London.

by product pulp. Compact accumulations or balls of the short fibres have been observed in the rumen of animals eating sisal by products. Gutiérrez (1981) and Belmar (1982) suggested that these formations contribute to the low rumen dilution rate and the poor voluntary intake of these by products.

The objectives of the present study were to compare ramón, a high quality forage, with a poor quality forage, african star grass (*Cynodon plectostachyus*) as supplements for diets based on ensiled sisal pulp and to study at the same time, the effect of the removal of the short fibres from the pulp on its voluntary intake by sheep. Also, the importance of the acid base imbalance detected in the first part of this study (Rodríguez et al, 1984) was evaluated.

Materials and Methods

Twelve Pelibuey and 12 Black Belly sheep, which were 9-11 months old and whose initial live weight ranged from 15 to 22 kg, were used. These animals had not had previous contact with sisal by products. They were housed in individual pens (see Rodríguez et al, 1984) to permit statistical analysis of feed intake data and were allocated according to their live weight to four treatments with three animals of each breed per treatment. The experimental design was a 2 x 2 x 2 factorial, the factors being; with and without short fibres in the sisal pulp ramón or african star grass as the forage source and breed - Pelibuey or Black Belly.

The ensiled sisal pulp (Rodríguez et al, 1984) was offered ad libitum as the basal diet. The pulp for the groups not receiving fibres was passed through a sieve made of chicken wire with a one inch mesh as it was removed from the silo. All animals received soya bean meal, urea and minerals, which along with the forages were offered in the quantities described by Rodríguez et al (1984).

Before the trial began the animals were treated against intestinal parasites. A ten day period was allowed for adaptation to the experimental diets which was followed by a 60 day period of measurements. The animals were weighed after a fast of 18 hours at the beginning of the experiment and then every 14 days. The intake of pulp by each animal was measured daily. During the two final days of the experimental period the weight of short fibres offered and refused was measured to allow for the possibility of a selective rejection of the fibres by the sheep.

Urine samples were obtained from all animals during the seventh week and then every two weeks until the end of the experiment. These samples were analysed for pH and net acid-base (NAB; Bartko et al, 1979). Blood samples, for the determination of blood pH, were taken one month after beginning the experiment and then every 14 days. The partial pressure of CO_2 (pCO_2) was also measured in the blood taken on the last two sampling days and the bicarbonate: carbonic acid ($\text{HCO}_3^-:\text{H}_2\text{CO}_3$) ratio calculated. The procedures of blood sampling and analysis were as described by Rodríguez et al (1984). To enable immediate analysis of the blood and urine samples they were taken from half of the animals on each of two consecutive days.

Four Pelibuey sheep of approximately the same age and live weight as the experimental group were housed in a separate pen and fed only ramón and african star grass ad libitum. These animals served as a control group for the physiological parameters measured.

Analysis of variance was used to estimate the importance of the main effects and their two factor interactions for the production and physiological parameters measured (Steel and Torrie, 1980).

Results and Discussion

Production: The mean values for dry matter (DM) intake, live weight (LW) gains and feed conversion are shown in Table 1.

Table 1

Voluntary intake, live weight gain and feed conversion in two breeds of tropical sheep fed ensiled sisal pulp with and without short fibres and with two sources of forage.

	Breed		Forage		Fibres		SED
	PB	BB	Ramón	Grass	With	Without	
Voluntary intake of pulp (kg DM/100 kg liveweight)	2.77	2.77	2.76	2.78	2.77	2.78	0.079
Live weight gain (g/animal/day)	81	70	81	69	77	74	12.4
Feed conversion (g DM intake/g live weight gain)	8.2	9.4	7.8	9.8	8.4	9.2	2.1

PB = Pelibuey

BB = Black Belly

SED = Standard error of difference

Plate 1

Compact accumulations of short fibres taken from the rumen of sheep fed diets based on sisal pulp.

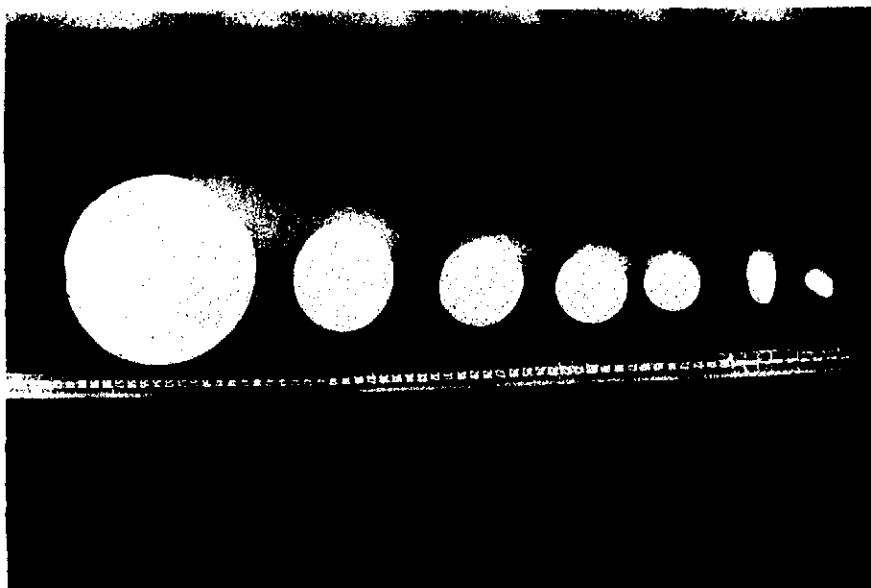


Table 2

pH and net acid base (NAB) in the urine in two breeds of tropical sheep fed ensiled sisal pulp with and without short fibres and with two sources of forage and in a control group fed forage.

	Breed		Forage		Fibres		Days of Trial			SED	Control	
	PB	BB	Ramón	Grass	With	Without	53	75			Mean	SE _x
pH	7.6	7.6	7.6	7.6	7.5	7.7	7.6 ^c	7.8 ^d	7.4 ^e	0.12	8.3	0.05
NAB (meq/L)	29.8	19.9	27.7	22.0	16.9 ^a	32.8 ^b	26.3	25.2	23.0	8.01	113.5	18.00

PB = Pelibuey
 BB = Black Belly
 SE_x = Standard Error of Mean

The means for each factor with different superscripts are significantly different:

a, b P < 0.05
 c, d, e P < 0.05 non-linear response

Voluntary intake of the sisal pulp was not significantly changed by any of the main factors studied. A significant ($P < 0.05$) interaction, however, was observed between breed of sheep and source of forage. The Pelibuey sheep ate more pulp with the star grass supplement than with ramón (2.89 vs 2.69% LW) whilst the Black Belly sheep ate more pulp with ramón (2.84% LW) than with star grass (2.71% LW).

The animals receiving sisal pulp with fibres consumed 64% and 90% of the short fibres with the supplements of ramón and star grass, respectively. The daily intake of pulp was about 90% of that offered. In spite of the consumption of considerable quantities of short fibres by the groups receiving whole pulp, the removal of the fibres did not appear to have any effect on voluntary intake. In this and the accompanying study (Rodríguez et al, 1984), the voluntary intakes of sisal pulp, expressed in proportion to LW, were considerably higher than those reported for cattle eating sisal by products. For example, Belmar and Riley (1984) fed ensiled sisal bagasse with a supplement of elephant grass at 25% of the total intake to young bulls and reported an intake bagasse DM of 1.3% LW. In sheep, however, the voluntary intake of pulp has generally been closer to 3% of LW (Sanguinez and Shimada 1978; Rodríguez et al 1981). It is possible therefore, that the removal of the short fibres from the sisal byproducts would improve their intake by cattle.

No significant effect of treatment on live weight gain ($P > 0.05$) was observed. The rate of gain, however, was slightly higher ($P < 0.1$) with ramón as the forage source than with star grass. Similarly, ramón tended ($P < 0.1$) to improve the feed conversion efficiency. These results in favour of ramón may be explained by the high nutritive value and digestibility of this forage (Yerena et al, 1978).

Physiology: The values for pH and NAB in urine are presented in Table 2.

Table 3
 Acid-base parameters in blood of sheep fed ensiled sisal pulp with and without short fibres, with two forage sources and of a control group fed forage.

	Breed		Forage		Fibre		Days of sampling			Control Mean	SE _X		
	PB	BB	Ramón - Crass	Ramón - Without	With	Without	33	47	61			75	SED
$\bar{P}_a\text{CO}_2$ (mmHg)	7.483	7.431	7.485	7.479	7.472	7.491	7.515 ^c	7.501 ^d	7.478 ^e	7.434 ^f	0.0089	7.426	0.0110
$\text{HCO}_3^-:\text{H}_2\text{CO}_3$	35.5	35.6	35.8	35.3	35.8	35.3	-	-	36.2 ^a	35.0 ^b	0.65	35.4	0.027
	22.8	22.1	22.9 ^a	22.0 ^b	22.2	22.7	-	-	23.5 ^a	21.4 ^b	0.45	21.2	1.9

PB = Pelibuey

BB = Black Belly

The means for each factor with different superscript are significantly different:

a, b P < 0.05

c, d, e, f P < 0.05 linear response

Significant differences ($P < 0.05$; non-linear response) between days of sampling were observed for urine pH. The interactions between breed and forage source ($P < 0.05$) and forage source and fibre ($P < 0.01$) were also significant.

NAB in the urine of sheep receiving the pulp without fibres (32.8 meq/l) was significantly higher ($P < 0.05$) than in those eating pulp with fibre (16.9 meq/l). A significant interaction ($P < 0.05$) between sampling day and type of forage was found for NAB. It is important to emphasize that the differences and interactions described above do not have great physiological significance. The values of pH and NAB in urine in all animals consuming sisal pulp were very much lower than those in the control group and are lower than the normal values reported in the literature for cattle in the tropics (Bartko et al, 1979; see Rodríguez et al, 1984).

The blood acid-base parameters are shown in Table 3.

Blood pH did not vary between treatments but a linear decrease ($P < 0.05$) with time was observed. A significant difference ($P \leq 0.05$) between days of sampling and significant interactions ($P < 0.05$) between breed and forage source and between sampling day and forage source were found for pCO_2 . The $HCO_3^-:H_2CO_3$ ratio was significantly higher ($P < 0.05$) after 61 days than after 75 days (23.5 vs 21.4). This ratio was also higher ($P < 0.05$) in animals fed ramon (22.9) than in those fed star grass (22.0).

As with urine, the significant differences between treatments found for blood parameters are not of biological importance, since all values were maintained close to or slightly higher than those for the control group.

A high excretion of hydrogen ions by the kidney, accompanied by a blood pH which tends to be high has been observed previously in animals consuming sisal by products (Belmar and Riley, 1984; Rodríguez et al, 1984). This phenomenon has been named a 'paradoxical aciduria' (Harper, 1980) and can be caused by a depletion of potassium ions, which results in an intracellular acidosis even when the plasma pH is elevated (Ganong, 1980). The condition may occur when steroidal compounds are administered (Harper, 1980). Sisal pulp and bagasse contain considerable quantities of saponins (Novelo, 1981), which are triterpenoids and therefore steroid precursors (Burns, 1978). These compounds may be implicated in the development of the condition detected in this study.

Conclusions

Although the animals in this study did not achieve the levels of production of those in the previous study (Rodríguez et al, 1984), it is interesting to note that in the presence of soya bean meal, ramon may be replaced by a lower quality and less expensive forage without a large reduction in growth rate.

The results of this study support those of Rodríguez et al (1984) and Belmar and Riley (1984), in that animals fed sisal by products did not suffer from severe acidosis when an adequate dietary supplementation was provided. However, a mild imbalance was detected, the importance of which to animal productivity remains unclear.

References

- Bartko P, Ortíz R and Boada A 1979 Métodos para la evaluación ácido-básica en la orina del ganado bovino alimentado con diferentes dietas. *Revista Cubana de Ciencia Agrícola* 13:1
- Belmar R 1982 Balance ácido-básico en toros alimentados con bagazo de henequén (*Agave fourcroydes*) fresco y ensilado. M Sc Thesis University of Yucatán México
- Belmar R and Riley J A 1984 Acid-base balance in young bulls fed ensiled sisal bagasse (*Agave fourcroydes*). *Tropical Animal Production* (In press)
- Burns J C 1978 Symposium: Forage quality and animal performance. *Journal of Dairy Science* 61:1809-1820
- Gutiérrez E 1981 Un estudio de la interacción digestiva entre la pulpa de henequén (*Agave fourcroydes*) ensilado y el zacate estrella (*Cynodon plectostachyus*). M Sc Thesis University of Yucatán México
- Gutiérrez E, Elliot R and Harrison D 1981 The effect of the supplement of african star grass on the digestibility of cellulose and rumen kinetics in male lambs receiving a basal diet of henequén pulp. *Tropical Animal Production* 6:361 (Abstract)
- Ganong W F 1980 Manual de Fisiología Médica 7th Ed El Manual Moderno México D F
- Harper H A 1980 Manual de Química Fisiológica 7th Ed El Manual Moderno México D F
- Novelo A R 1981 El henequén como fuente de esteroides. I Simposio del Agave, Cordemex Mérida Yucatán México
- Rodríguez A A, Castellanos A, Bernal G and Shimada A S 1981 Efecto de la adición de nitrógeno, energía e isoácidos a la pulpa fresca de henequén sobre el crecimiento del borrego Pelibuey en confinamiento. *Técnica Pecuaria en México* 41:22-31
- Rodríguez A, Riley J A and Thorpe W 1984 Animal performance and physiological disturbances of sheep fed diets based on ensiled sisal pulp (*Agave fourcroydes*). The effect of supplementation with protein, forage and mineral. *Tropical Animal Production* (In press)
- Sanguines G R and Shimada A 1978 Valor nutritivo de los subproductos de henequén (*Agave fourcroydes*) para el borrego Tabasco. *Técnica Pecuaria en México* 34:16-20
- Steel R and Torrie J H 1980 Principles and procedures of statistics. A Biometrical Approach 3rd Ed McGraw-Hill Kogakush Ltd Tokyo
- Yerena F, Ferreiro H M, Elliot R, Godoy R and Preston T R 1978 Digestibility of ramón (*Brosimum alicastrum*), Leucaena leucocephala, buffel grass (*Cenchrus ciliaris*), sisal pulp and sisal bagasse (*Agave fourcroydes*). *Tropical Animal Production* 3:27-29

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