

ANIMAL PERFORMANCE AND PHYSIOLOGICAL DISTURBANCES IN SHEEP FED DIETS BASED ON ENSILED SISAL PULP (*Agave fourcroydes*) I THE EFFECT OF SUPPLEMENTATION WITH PROTEIN, FORAGE AND MINERALS

Rodríguez A¹ Riley Judith A¹ and Thorpe W¹

Facultad de Medicina Veterinaria y Zootecnia
Universidad de Yucatán
Apdo. Postal 116-D
97100 Mérida, Yucatán, México

Thirty-two male Pelibuey lambs were used to investigate the most appropriate means of supplementing diets based on ensiled sisal pulp (*Agave fourcroydes*) for sheep, and to detect possible metabolic disturbances caused by such diets. The animals were divided into eight treatment groups in a 2 x 2 x 2 factorial experiment. The factors were, the presence or absence of a protein supplement (soya bean meal), a forage supplement (ramon; *Brosimum alicastrum*) and a mineral supplement. Ensiled sisal pulp was offered ad libitum as the basal diet. All the diets were made isonitrogenous (15% CP) by the addition of urea. The experiment lasted 112 days.

The addition of the supplements increased the voluntary intake (VI) of the basal diet (pulp/urea) by 2%, 19% and 8% for ramon, soya and both respectively. Similarly, the VI tended to improve with the addition of the mineral supplement. Both the ramon and the soya bean meal significantly improved live weight gains ($P < 0.01$), but with the mineral supplement the increase was not significant ($P > 0.05$). A satisfactory rate of live weight gain (125 ± 10.1 g/day) was obtained when all the supplements were offered simultaneously. Changes were detected in the acid-base balance of the animals, but these were less severe than those reported previously in cattle fed sisal by-products.

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

Since the first attempts to use the by-products of the sisal industry (pulp and bagasse) as animal feeds, it has been apparent that acceptable levels of animal production will not be attained without an adequate dietary supplementation (see Belmar and Riley, 1984; Harrison, 1984).

The most promising responses in animal production have usually been obtained with protein supplements. In both cattle and sheep, several authors have reported an improvement in animal performance and voluntary intake of the by-products with supplements containing true protein, especially when these are resistant to degradation in the rumen, as is fish meal (Sanguines et al, 1976; Sanguines and Shimada, 1978; Godoy and Elliot, 1979; Herrera et al 1980).

One of the factors which may cause the low voluntary intake of pulp and bagasse is a low turnover rate of rumen digesta (Ferreiro et al, 1978). Gutiérrez et al (1981) significantly increased ($P < 0.05$) both the dilution rate of the rumen liquid phase and the voluntary intake of sisal pulp by including a forage supplement, african star grass (*Cynodon plectostachyus*), in the diet of sheep at 25% of the total daily intake.

Harrison (1984), recently carried out analyses which show that the sisal by-products contain low levels of the minerals phosphorus (P), copper (Cu), cobalt (Co), manganese (Mn) and zinc (Zn) but are high in calcium (Ca) and

¹Technical Cooperation Officer, Overseas Development Administration, London

magnesium (Mg). This author suggests therefore, that the efficient use of these feedstuffs will require supplementation with minerals.

Disturbances in the acid-base balance of young bulls eating sisal bagasse or pulp have been reported (Naseeven and Harrison, 1981; Belmar and Riley 1984). These may explain, in part, the poor animal performance and voluntary intake with such diets. The nature and importance of these disturbances, however, are still not fully understood.

The present study was carried out to integrate previous results by evaluating the combined action of forage, protein and mineral supplements. Acid-base balance was also studied to determine its importance in terms of animal productivity.

Materials and Methods

Thirty-two male Pelibuey sheep were used. They were 10 to 12 months old at the beginning of the experiment and weighed between 14 and 21 kg. These animals had not had previous contact with sisal by-products, and were treated against intestinal parasites before the trial began. They were distributed at random in groups of four each with a mean live weight of 17 ± 2 kg, in wooden pens with a cement floor and artificial shade. Water was available ad libitum.

The experimental design was a 2 x 2 x 2 factorial, the factors being with and without protein supplement, with and without forage and with and without minerals. The four animals in each treatment combination were housed in a single pen. All animals received ensiled sisal pulp ad libitum as the basal diet. The fresh pulp was ensiled without additives in silos with a three tonne capacity. Soya bean meal was offered as the protein supplement at 12% of the total voluntary dry matter intake (DMI), which provided 32% of the total dietary crude protein (CP). Ramon (*Brosium alicastrum*), freshly cut and chopped each day, was offered as the forage source at 30% of DMI. Mineral mixes were made for each diet, taking into account the mineral composition of the ingredients, to provide 150% of the nutritional requirements for P, Mn, Cu, Co and Zn (McDonald et al, 1973). The diets were made isonitrogenous (15% CP) by the addition of urea. The composition of the dietary ingredients is shown in Table 1. Half of the sisal pulp was offered in the morning with the supplements, the remaining 50% was fed in the afternoon. Enough pulp was offered to ensure a refusal of at least 10%.

The experiment lasted 112 days, of which the first 14 were the period of adaptation to the experimental diets. The animals were weighed at the beginning of the experiment and then every 14 days, after a fast of 18 hours. The intake of pulp was measured daily for each pen.

To detect any possible changes in the acid-base equilibrium of the animals, urine samples were taken from the fifth day of the trial. A sample was taken from one animal in each pen each week, each animal was therefore sampled once each month. The urine samples were analysed for pH and net acid-base (NAB; Bartko et al, 1979). Eight animals were selected at random before the experiment began, when they were grazing african star grass, and blood samples were taken to determine blood pH. At the end of the trial blood samples were taken from the jugular vein of all animals with a heparinised syringe. The pH and partial pressure of CO₂ (pCO₂) of the samples were determined in a blood gas analyser (BGA3, Radiometer Copenhagen). The blood pH and pCO₂ values obtained were used to calculate the bicarbonate:carbonic acid ratio (HCO₃⁻:H₂CO₃).

Analysis of variance was used to determine significant factor effects and interactions (Steel and Torrie, 1980).

Table 1

The composition of the ingredients of the experimental diets.
(*DM basis)

	Soya bean meal	Ramon forage	Ensiled sisal pulp
Dry matter (%)	88.6.	39.1	19.9
Crude protein (%)*	45.5	17.2	5.8
Calcium (%)*	0.3	1.3	5.0
Phosphorus (%)*	0.40	0.11	0.04
<u>Trace Elements (ppm)</u>			
Zn*	625	20	14
Mn*	34	16	10
Fe*	142	59	112
Cu*	26	5	4
Co*	2	ND	ND

ND = not detectable

Results and Discussion

Production: The mean voluntary DMI of both sisal pulp and the total diets for each treatment during the 98 days of the trial are shown in Figure 1.

The inclusion of the supplements in the diet increased the DMI of the basal diet (pulp/urea) by 2%, 19% and 8% for ramon, soya bean meal and both, respectively. The mineral supplement also tended to increase the DMI, especially in the presence of one or more of the other supplements. The soya bean meal caused the largest increases in the consumption of the basal diet 35% with and 19% without the mineral supplement.

This stimulation of voluntary DMI of the pulp by soya is similar to that reported by Rodríguez et al (1981), who also used soya bean meal as a protein supplement. The lack of response to the forage supplement, however, differs from the results of Gutiérrez et al, (1981), who obtained an increase in the total voluntary DMI by sheep of 70% with the inclusion of african star grass at 25% in diets of sisal pulp. On the other hand, the addition of ramon to sisal pulp in diets for cattle reduced the voluntary intake of the by-product (Priego et al, 1979).

The effects of supplementation on changes in live weight are shown in Figure 2. Both ramon and soya caused significantly ($P < 0.01$) greater live weight gains than those of the groups consuming pulp alone or with only minerals. The addition of minerals improved the performance of the animals, but this effect was not significant ($P > 0.05$). These results are presented in Table 2.

Table 2

Mean liveweight changes of sheep fed basal diets of sisal pulp and receiving supplements of soya bean meal, ramon and minerals.

	SUPPLEMENT						SED*
	Soya bean meal		Ramon		Minerals		
	-	+	-	+	-	+	
Live weight changes (g/animal/day)	1.6 ^a	82.4 ^b	10.3 ^a	73.7 ^b	33.4	50.6	14.20

*SED- Standard error of the difference

Means for each factor with different superscripts are significantly different $P < 0.01$

Figure 1

Effect of the addition of supplements to a diet of ensiled sisal pulp/urea on the voluntary DM intake of Pelibuey sheep

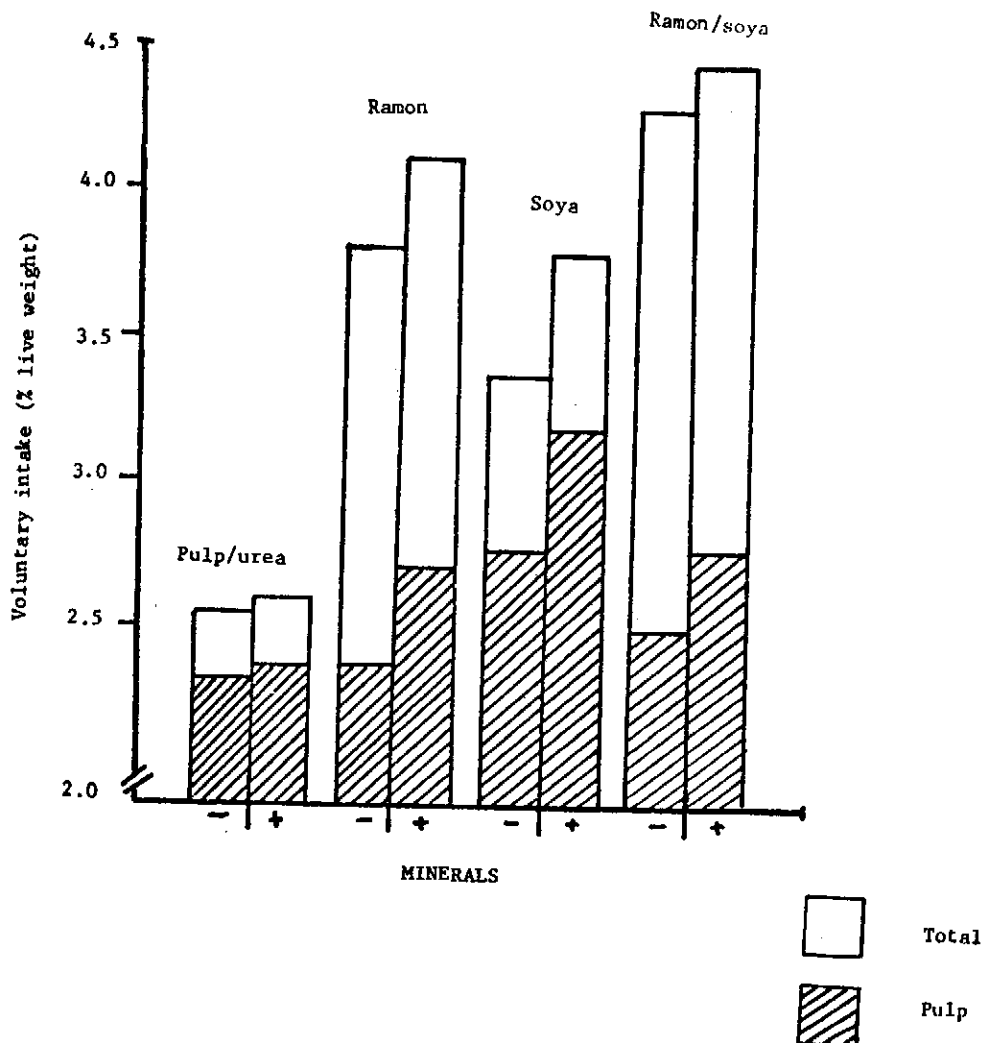
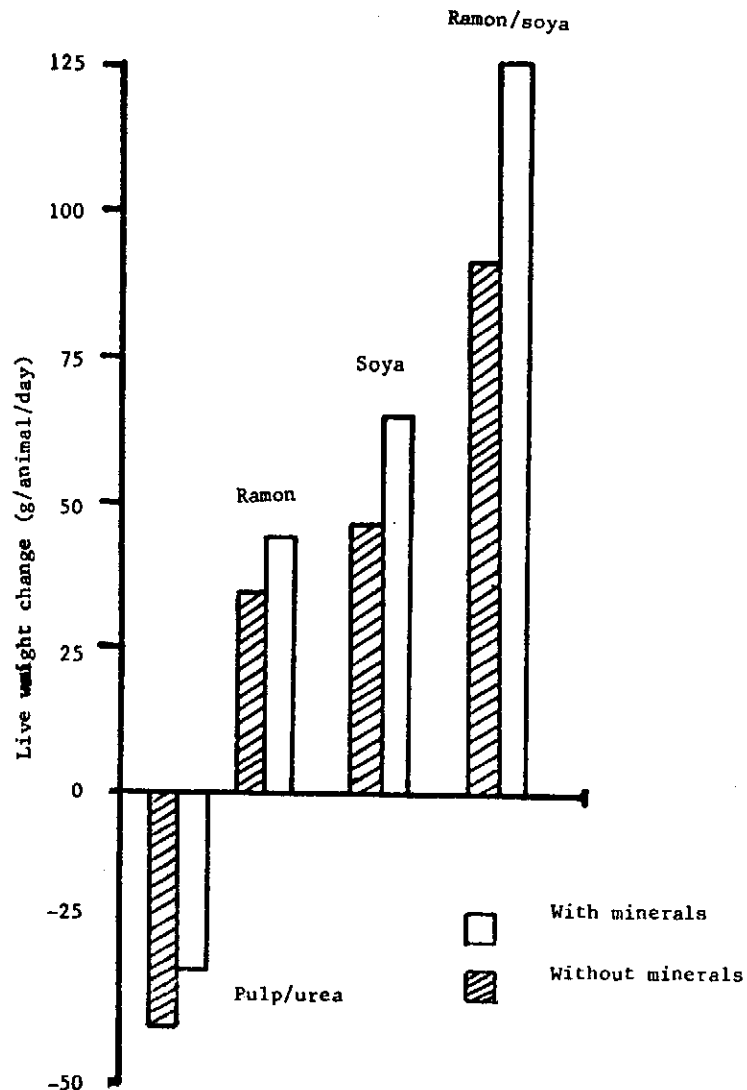


Figure 2

Effect of the addition of supplements to a diet of ensiled sisal pulp/urea on live weight changes in Pelibuey sheep.

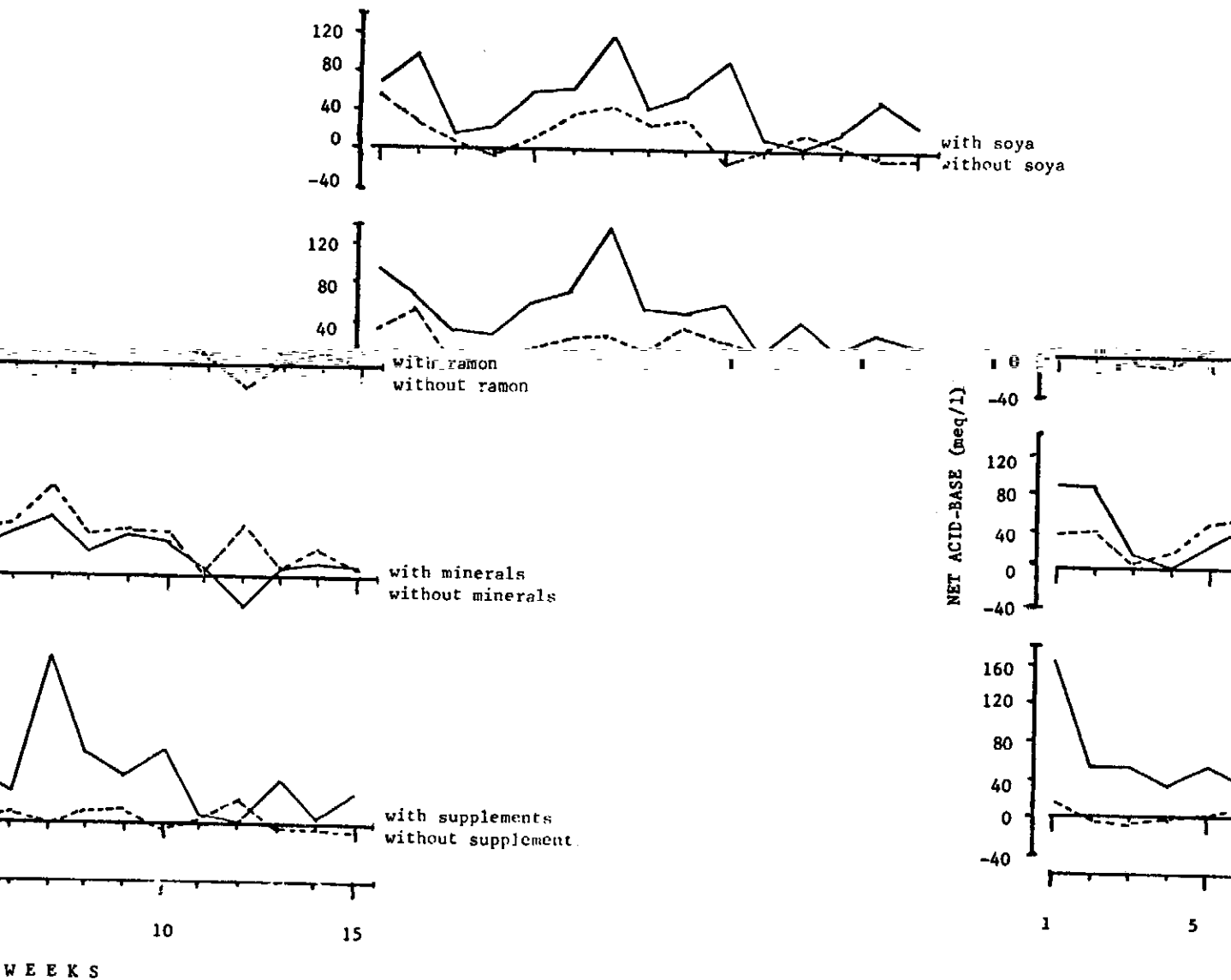


No significant interactions were found between the different types of supplement.

In general the increases in live weight gain were directly related to the quantity of true protein administered, a result similar to those reported for sheep by Sanguines and Shimada (1978) and Rodríguez et al (1981). The consistent improvement in intake and growth rate observed with the mineral supplement indicates the importance of this type of supplementation for the efficient use of the sisal by-products.

Figure 3

Effect of the addition of supplements to a diet of ensiled sisal pulp/urea on net acid-base in the urine of Pelibuey sheep.



acid-base in urine during the 15 weeks of the experiment are shown in Figure 3. Although the results for this parameter were very variable from week to week, the addition of ramon or soya to the diet tended to increase the net acid-base values, whereas minerals did not. The experimental diet of sisal pulp plus ramon, soya and minerals, showed that net acid-base was maintained close to zero in the control animals, whereas with the supplements the values were higher until the 10th week of the trial, but by the 11th week they had fallen close to those in the animals not receiving any supplements. In a

Physiology: Values for net acid-base in the experiment are shown in Figure 3. Although the results for this parameter were very variable from week to week, the addition of ramon or soya to the diet tended to increase the net acid-base values. Under extreme treatments, pulp alone and pulp plus ramon, soya and minerals, are shown in the lower graph. Net acid-base was maintained close to zero in the control animals not receiving supplements, whereas with the supplements the values were higher until the 10th week of the trial, but by the 11th week they had fallen close to those in the animals not receiving any supplements. In a

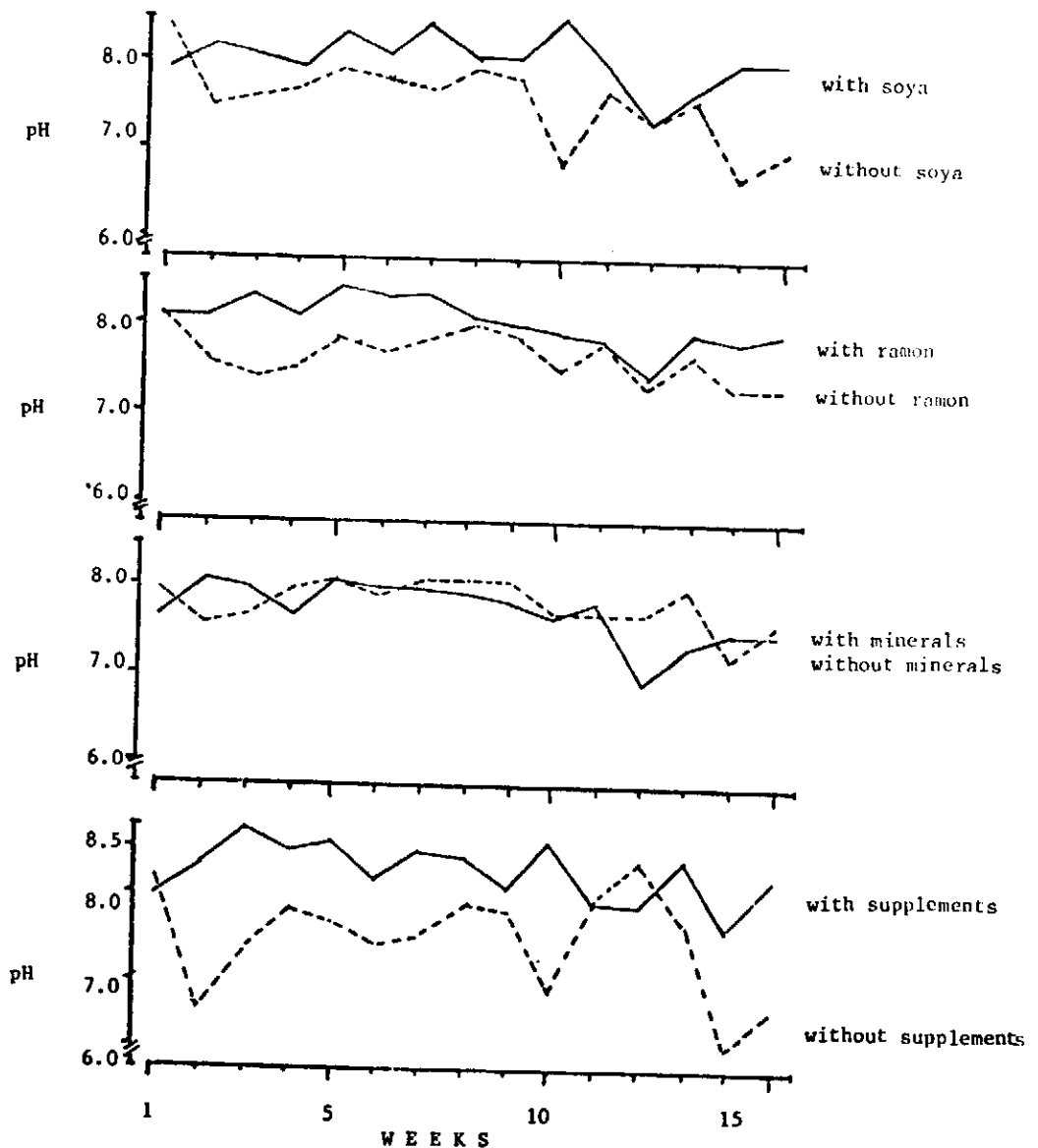
similar manner, supplementation largely prevented the fall in urine pH observed when the animals began consuming sisal pulp (Figure 4).

Bartko et al (1979) present the following classification of acid-base balance, based on net acid-base in the urine of cattle.

> 100 meq/l	-	normal
100-0 meq/l	-	compensated metabolic acidosis
< 0 meq/l	-	uncompensated metabolic acidosis

Figure 4

Effect of the addition of supplements to a diet of ensiled sisal pulp/urea on the urine pH of Pelibuey sheep.



On the basis of this classification and the urine pH values, it is possible to diagnose a state of compensated acidosis, this condition being worse in those animals which did not receive an adequate supplementation. However, it is difficult to diagnose the condition categorically in the absence of published normal ranges for the species/breed of animal used and the environmental conditions of the experiment. At a later date, Rodríguez et al (1984) established that Pelibuey sheep at the same site and consuming african star grass and ramon had mean values for NAB and pH in urine of 113 meq/l and 8.3, respectively. This reinforces the diagnosis mentioned above.

The reference blood pH obtained from eight animals before the experiment began was 7.41 (range 7.38 - 7.45). Mean values for pH, pCO_2 and $HCO_3^-:H_2CO_3$ in blood of animals receiving the eight experimental diets are shown in Table 3. The presence of ramon or soya in the diet significantly increased ($P < 0.05$) the blood pH. Animals receiving ramon had significantly lower ($P < 0.01$) values of pCO_2 than those which did not receive this supplement, and significant interactions ($P < 0.05$) between ramon and soya and between ramon and minerals were observed. The ratio $HCO_3^-:H_2CO_3$ was significantly higher ($P < 0.01$) in animals receiving soya and ramon, and the interaction between these two supplements was significant ($P < 0.05$).

Tasker (1980) reports normal values for blood pH, pCO_2 and $HCO_3^-:H_2CO_3$ of 7.4, 40mmHg and 20:1, respectively. The blood pH value is very similar to the reference pH obtained in this study. Of the differences and interactions previously described, the result of major interest is the low pH and high pCO_2 of the groups which did not receive soya or ramon. This agrees with the diagnosis made from urine parameters, that is a mild acidosis. However, by the end of the experiment these animals were in very bad condition.

The relatively high values of pH and $HCO_3^-:H_2CO_3$ and low values of pCO_2 in the supplemented groups may be explained, in part, by the high temperatures in the tropical conditions under which the experiment was conducted. A high rate of respiration in a hot environment increases the loss of CO_2 , which in turn increases blood pH (Tasker, 1980). This apparent alkalosis does not agree with the results reported for urine parameters. However, Belmar and Rieley (1984) observed a similar phenomenon in cattle fed ensiled sisal bagasse.

Table 3

Acid-base parameters in blood of sheep fed ensiled sisal pulp with and without supplements for 100 days.

	SUPPLEMENTS								
	Without Soya bean meal				With Soya bean meal				SED
	Without ramon		With ramon		Without ramon		With ramon		
	Minerals		Minerals		Minerals		Minerals		
Without	With	Without	With	Without	With	Without	With		
pH	7.40	7.42	7.48	7.49	7.49	7.47	7.48	7.49	0.035
pCO_2 (mmHg)	47.1	41.7	34.8	37.9	40.4	37.8	38.0	38.7	2.25
$HCO_3^-:H_2CO_3$	19.4	20.5	23.5	23.3	24.2	22.8	23.9	23.7	1.21

Conclusion

The results from this study emphasize the importance of an adequate supplementation of diets based on sisal by-products. An acceptable level of production was obtained with supplements of true protein, forage and minerals. This type of supplementation is expensive, therefore it is proposed that future work should investigate cheaper alternatives to the supplements used.

The sheep consuming sisal pulp suffered from an acid-base imbalance. This disturbance was not as severe as that observed by Naseeven (1981) in young bulls fed ensiled sisal pulp. Further, the imbalance was less severe in animals receiving supplements of ramón and soya, therefore it is not considered that it is one of the principal factors which limit animal performance with diets based on by-products of the sisal industry, when an adequate supplementation is provided.

References

- Bartko P Ortíz R and Boado A 1979 Métodos para la evaluación ácido-básica en la orina del ganado bovino alimentado con diferentes dietas Revista Cubana de Ciencias Agrícolas 13:1
- Belmar R and Riley J A 1984 Acid-base balance in young bulls fed ensiled sisal bagasse (*Agave fourcroydes*) Tropical Animal Production (in press)
- Ferreiro H M Elliot R Ríos V and Preston T R 1978 Rumen function and fermentation on sisal pulp based diets Tropical Animal Production 3:69-73
- Godoy R and Elliot R 1979 Effect of supplements of sorghum grain and fish meal on the intake and growth of bulls fed henequen pulp or bagasse Tropical Animal Production 4:183 (Abstract)
- 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 henequen pulp Tropical Animal Production 6:361 (Abstract)
- Harrison D C 1984 The use of sisal by-products as feed for ruminants World Animal Review 49:25-32
- Herrera F Wyllie D and Preston T R 1980 Fattening steers on a basal diet of ensiled sisal pulp and molasses/urea supplemented with sunflower meal and Leucaena forage Tropical Animal Production 5:18-24
- McDonald P Edwards R A and Greenhalgh J F D 1973 Animal Nutrition 2nd Ed Oliver and Boyd Edinburgh
- Naseeven R 1981 Estado de equilibrio ácido-base en ganado bovino alimentado con una dieta básica de bagazo de henequén ensilado y efecto sobre la producción animal (Abstract) Congreso Nacional AMENA Veracruz México
- Naseeven R and Harrison D 1981 Metabolic disorder in bulls fed with henequen pulp Tropical Animal Production 6:361-362 (Abstract)
- Priego A Elliot R and Preston T R 1979 Studies on digestion in the forestomachs of cattle of a diet based on sisal pulp: II Supplementation with ramon (*Brosimum alicatum*) forage and rice polishings Tropical Animal Production 4:287-291
- Rodríguez A A Castellanos A Bernal G and Shimada A S 1981 Efecto de la adición de nitrógeno, energía y 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 in sheep fed diets based on ensiled sisal pulp (*Agave fourcroydes*): II The effect of forage source and removal of short fibres Tropical Animal Production
- Sanguines G R Carrasco B Martínez L Salinas E and Shimada AS 1976 Composición proximal del bagazo de henequén y su uso en la alimentación del borrego Técnica Pecuaria en México 31:75-78
- Sanguines G R and Shimada AS 1978 Valor nutritivo de los subproductos del henequén (*Agave fourcroydes*) para borregos Tabasco Técnica Pecuaria en México 34:16-20
- Steel R and Torrie J H 1980 Principles and Procedures of Statistics a biometrical approach 2nd Ed McGraw-Hill Kogakush Ltd Tokyo Japan
- Tasker J B 1980 Fluids, Electrolytes and Acid-Base Balance In Clinical Biochemistry of Domestic Animals p 402-444 (Ed J J Kaneko) Academic Press New York