THE EFFECT OF WHEAT BRAN ON RUMEN FERMENTATION, RUMEN VOLUME AND FLUID FLOW RATE IN ZEBU BULLS FED CHOPPED WHOLE SUGAR CANE

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Four Zebu bulls fitted with permanent rumen cannulae were used in a 4 x 4 latin square. They were given a basal diet of chopped whole sugar cane (25.0% DM, 11.8: Brix) plus 9 g urea and 2.5 g ammonium sulphate per kg fresh cane, and a phosphorus calcium salt mineral mixture. They were supplemented with 0, 500, 1000 or 1500 g/d wheat bran. Supplementation with wheat bran had no effect on the voluntary intake of cane, nor on rumen pH, total VFA levels or VFA proportions. Rumen volume (measured with PEG) was not affected, but fluid flow rate wee increased. The rumen volumes for the control and increasing levels of wheat bran were 28, 31, 32 and 28 ± 2.7 1 and fluid flow rates were 25, 26, 37 and 31 ± 2.6 1/d. The rate of degradation of the wheat bran was measured using disappearance from dacron bags suspended in the rumen. It was found that of the dry matter lost from the bags in the rumen in 24 hours, 80% was lost in the first three hours. Some 80% of this could be explained as being water soluble or miscible. An attempt was made to estimate the amount of protein leaving the rumen by precipitating the protein from the rumen fluid with trichloracetic acid (TCA) and combining this with fluid flow rates. This gave flows of 75, 81, 153 and 124 ± 17 g protein/d. It is concluded that the rumen fermentation of cane fed animals is very stable (as measured by pH x VFA levels) and that, not withstanding the errors involved, there was evidence that the flow of protein to the abomasum of unsupplemented animals was low and was increased by supplementation.

Key Words: Cattle, sugar cane, supplementation, wheat bran, rumen parameters

Priego et al (1977) have shown that when cassava-root meal or rice polishings were used to supplement diets of chopped sugar cane there was little effect on rumen pH, VFA levels or proportions, Rice polishings did however have the effect of increasing fluid flow rate, but no other effects were observed. The growth response to the supplementation of cane diets with wheat bran, and the digestibility of such diets has been reported (Silvestre and Hovell 1978; Marte et al 1978). The objective of the experiment reported here was to measure the effect of supplemental wheat bran on some of the parameters of rumen fermentation.

Materials and Methods

Animals, Treatments and Design: Four Zebu bulls fitted with permanent rumen cannulae, and of approximately 180 kg liveweight and about two years old were used in an experiment of latin square design. The periods were of three weeks. Four dietary treatments were imposed, namely:

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A. Control
   Chopped whole sugar cane ad libitum, supplemented with 9 g urea and 2.5 g ammonium sulphate per kg fresh cane (given as a solution in water mixed into the cane), plus 80 g/d of a mineral supplement (50:50 calcium diphosphate and salt).
B. As A, plus 500 g/d wheat bran.
C. As A, plus 1000 g/d wheat bran.
D. As A, plus 1500 g/d wheat bran.

Management and Sampling: The bulls were tethered in individual stalls under cover, and were individually rationed and fed once daily at about 09.00 hours. The sugar cane (whole cane including tops and leaves) was chopped just before feeding, using a Gehl forage harvester, the pieces being of up to about 2 cm in length. The supplement was given on top of the cane immediately after feeding the cane, and the refusal measured the following morning with the assumption that it consisted of cane only. Rumen liquor samples were taken on the last day of each period, immediately before feeding (time 0) and at 2, 4, 6, 8, 11, 15 and 24 hours after feeding. The samples were strained through a domestic sieve and sub-samples taken, preserved and stored at about +1°C for subsequent analysis.

Measurements:

Rumen pH: Was measured on the fresh liquor using a Beckman Zeromatic SS-3 pH meter.

Volatile Fatty Acids: (VFA): Were determined on a sample which had been preserved with 5.0 N H_2SO_4 (2-3 drops in 10 ml). Total VFA by Markham distillation, and molar proportions by gas chromatography of an ether extraction of the preserved liquor as described by Minor et al (1977).

Ammonia and Protozoal Biomass: Were also determined as described by Minor et al (1977).

TCA Precipitable Nitrogen: The nitrogen precipitable by a 10% (w/v) solution of trichloroacetic acid (TCA) was determined as follows: an equal volume of 20% TCA was added to 7 ml of fresh rumen liquor strained through a domestic colander with holes of about 1.5 I square. This was then mixed, cooled in a refrigerator for 15 minutes, and then centrifuged. The supernatant was decanted and discarded. The nitrogen content of the precipitate was then determined by semi-micro kjeldahl with a copper sulphate, selenium oxide mixture as catalyst. No difference could be found in the amount of precipitable nitrogen recovered by centrifugation or by filtration using Whatman #40 paper.

Rumen Volume and Fluid Flow: Were determined from rumen fluid concentration of PEG, and its change with time after dosing by the method of Hyden (1961). PEG was determined by the method of Malawar and Powell (1967).

Wheat Bran Degradation: The rate of disappearance of the dry matter of wheat bran was measured using dacron bags. About 10 g sample was placed in a dacron bag measuring about 8 x 11 cm, closed by a draw-string. Five bags were placed in the rumen just before feeding; and one bag was with drawn after 3, 6, 9, 12 and 24 hours. The bags were thoroughly washed and dried to constant weight at 65°C (Rodriguez 1968; Mehrez and 0rskov 1977).

Results and Discussion

Voluntary Intake: There was no statistically significant effect of wheat bran on cane intake as is shown by Table 1. The general tendency was for the intakes of cane and wheat bran to be cumulative, as has been our earlier experience (Silvestre and

Table 1 :
Food consumption and rumen parameters of Zebu bulls given chopped whole sugar cane supplemented with wheat bran (means of 4)

	Treatment				SEx
	A	B	C	D	
Daily intake, kg DM					
Wheat bran	-	0.44	0.88	1.32	-
Chopped whole cane[1]	2.87	2.35	2.93	2.48	0.27
urea	0.10	0.09	0.10	0.09	-
Ammonium sulphate	0.03	0.02	0.03	0.02	-
Minerals[2]	0.08	0.08	0.08	0.08	-
Total	3.08	2.98	4.02	3.99	-
Rumen parameters[3]					
pH	6.35	6.47	6.35	6.39	0.10
Total VFA, mequiv/1	111	119	113	118	15
Molar proportions VFA, %[4]					
Acetic	63	64	62	59	2.9
Propionic	22	22	22	22	2.6
Butyric	14	16	15	17	2.9
Ammonia, mg/1 [5]	210	185	243	247	27[6]
Precipitable protein,g/1[7]	3.18	2.93	4.17	3.72	0.56
Protozoal biomass,% fluid vol	0.32	0.42	0.33	0.42	0.11
Rumen fluid[8]					
Volume 1	28	31	32	28	2.7
Flow, 1/d	25	26	37	31	2.6
Turnover, vols/d	0.9	0.9	1.3	1.2	0.11

[1] In periods 1 to 4 respectively, the cane had 25.4, 24.9, 25.2 and 24.3% DM, and 12.0, 11.8, 12.0 and 11.2° Brix (spectrometer)
[2] 50:50 mixture of dicaldium phosphate and salt
[3] Each value is the mean of 7 observations on each of 4 animals taken at 0, 2, 4 6, 8, 11 and 15 h after feeding
[4] Values do not always sum to 100 (see 3 above)
[5] Mean of three periods only
[6] Three periods only. SE is average of within treatment variance
[7] Nx 6.25 precipitated with 10% TCA from strained liquor
[8] Measured with polyethylene glycol (PEG)

Table 2:
The effect of different supplements on some parameters of rumen fermentation in cattle fed chopped whole sugar cane

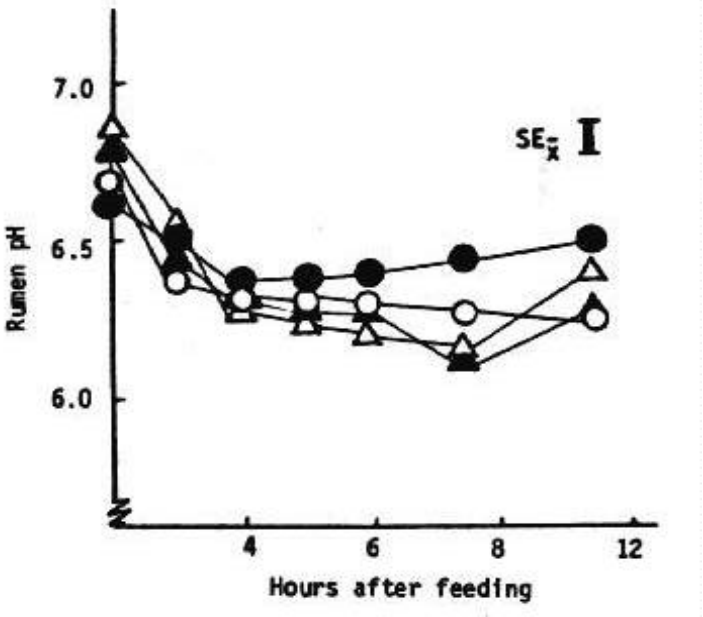
Source	Supplement			Rumen parameters		3-4 post feeding		
				pH	Total VFA	VFA molar %		
	Type	kg/d	% DMI		(emquiv/1)	[1] Acetic	Propionic	Butyric
Minor et al (1977)	-	Nil	-	6.6±0.2	149±23	59±4	28±3	14±2
	-	Nil	-	6.6±0.1	115±8	56±2	30±2	14±1
	Rice polishings	1.0	N/A	6.6±0.2	122±25	53±5	30±2	17±2
	Cotton seed meal	0.6	N/A	6.6±0.1	122±11	55±2	28±1	17±1
	Ground maize	1.0	N/A	6.5±0.02	142±25	54±10	26±1	20±3
	Ground maize	2.0	N/A	6.4±0.08	144±18	56±3	27±2	17±1
Priego et al (1977)	-	-	-	6.36±0.05	124±8	72±1	19±1	8±1
	Rice polishings	1.5	23	6.10±0.05	149±8	72±1	21±1	7±1
	-	-	-	6.36±0.06	161±11	75±2	18±2	7±2
	Cassava root meal	1.2	27	6.18±0.06	120±11	74±2	18±2	8±2
This experiment[2]	-	-	-	6.34±0.10	106±15	62±3	23±3	15±3
	Wheat bran	1.5	35	6.36±0.10	113±15	62±3	22±3	16±3

[1] Percent dietary dry matter (DMI) N/A not available
[2] Average 2-6 h post feeding

Hovell 1978; Marte et al 1978). There was certainly no indication that wheat bran stimulated cane intake as has been reported with rice polishings (Preston et al 1976; Lopez et al 1976; Lopez and Preston 1977); although it should be noted that these were feeding trials and that Priego et al (1977) did not note any effect of rice polishings on cane intake in an experiment of latin square design with periods of two weeks.

Rumen pH, Total VFA and VFA Proportions: There was no effect of supplementation with wheat bran on any of these parameters as is shown by Table 1 and Figures 1 to 5. Rumen fermentation on cane diets, as judged by these parameters, appears to be very stable, and is not detectably affected by supplementation as is demonstrated by Table 2 which summarises data from the literature. - The only clear effect in the experiment reported here, was that with all diets, Acetate tended to fall, and Propionate to rise immediately after feeding (Figures 3 and 4). After four hours they then began to revert to their former levels. Butyrate (Figure 5) remained relatively stable throughout the day. Priego et al (1977) observed a similar tendency.

Figure 1:
The rumen pH of Zebu bulls given chopped whole sugar cane supplemented with 0(○) , 500 (●), 1000 (△) or 1500 (▲) g/d wheat bran (means of 4)



Rumen Ammonia: Data are limited to three periods only. However, there was no effect of level of supplement (Table 1). Rumen ammonia levels reached their peak 4 hours post feeding (Figure 6).

Rate of Wheat Bran Degradation: It had been intended to measure this at weekly intervals throughout the experiment. Unfortunately it was impossible to complete this

Figures 2-5:
Total Volatile Fatty Acid (VFA) levels, and molar proportions in the rumens of Zebu bulls given chopped whose sugar cane supplemented with 0(○), 500 (•), 1000 (△) or 1500 (▲) g/d of wheatbran (means of 4)

Figure 2.

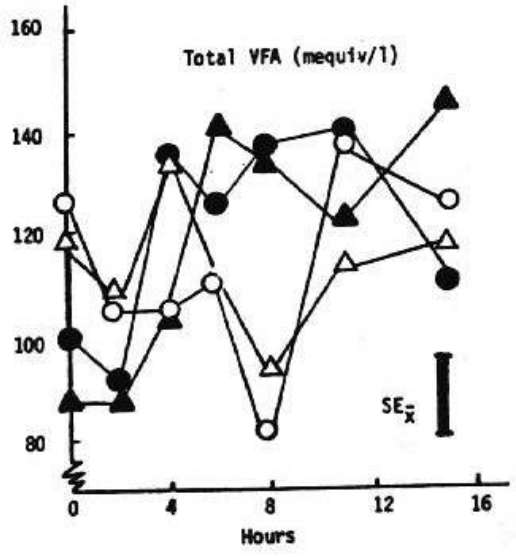


Figure 3.

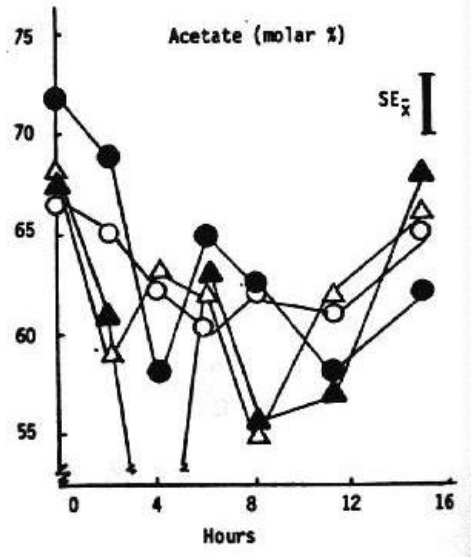


Figure 4.

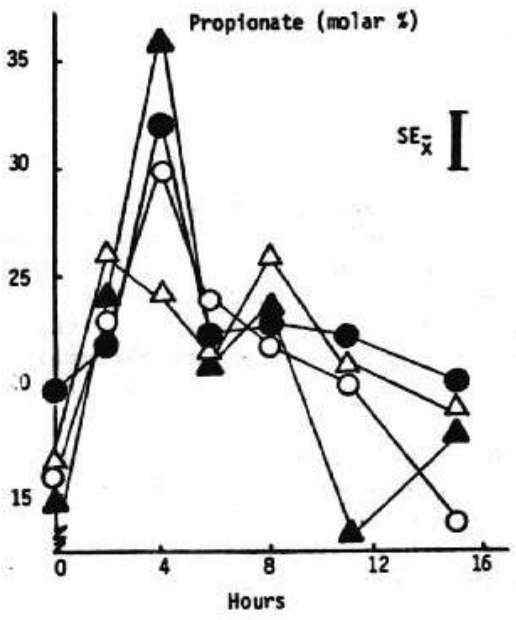


Figure 5.

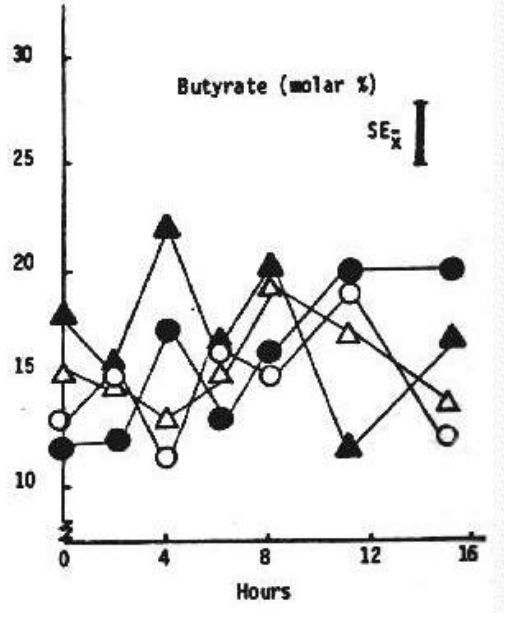
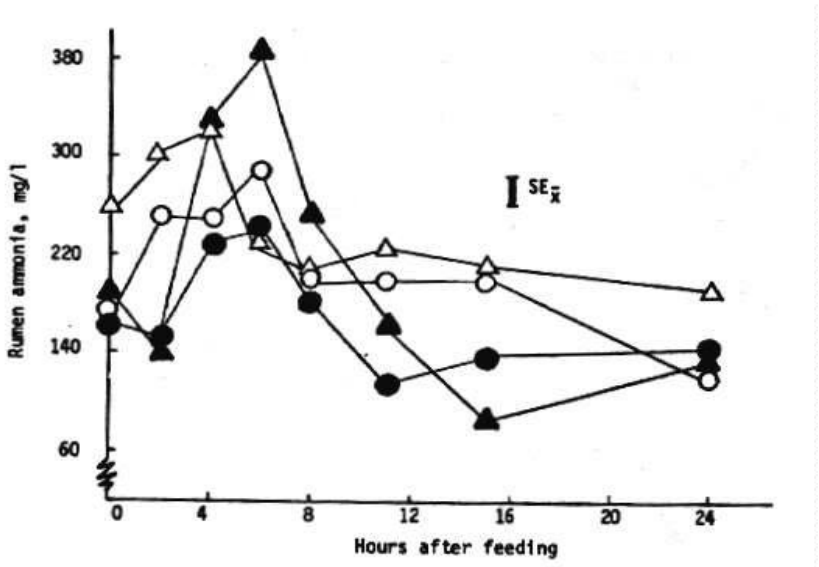


Figure 6:
The rumen ammonia of Zebu bulls given chopped whose sugar cane/urea supplemented with 0(○), 500 (●), 1000 (△) or 1500 (▲) g/d wheat bran



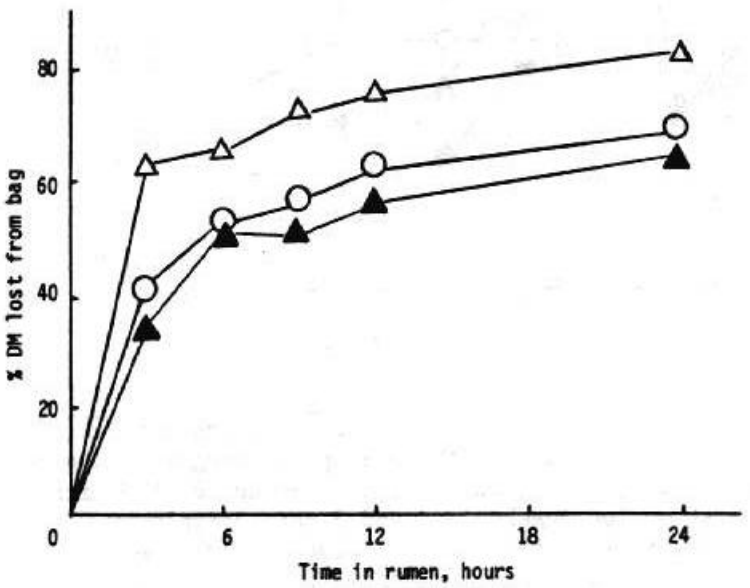
programme. Therefore the results presented in Table 3 and Figure 6 relate to the week proceeding the experiment (when the animals were eating cane/urea only) and the end of the first and second weeks of the first period (weeks 1, 2 and 3 respectively in Table 3). There were no obvious effects of supplementation, and the data were bulked within weeks. Two things are clear from Table 3 and Figure 7.

Table 3:
The rate of dry matter loss of wheat bran from dracon dacron bag.s suspended in the rumen of Zebu bulls given chopped sugar cane (means of 4)

	Week No	Hours in rumen					
		3	6	9	12	24	SEx
Percent dry matter (DM)loss	1	62	66	72	75	81	4.4
	2	34	51	51	55	64	4.4
	3	41	52	57	63	68	-
Percent of 24 hour DM loss	1	77	81	89	92	100	-
	2	53	80	80	86	100	-
	3	60	76	84	93	100	-
	X	63	79	84	90	100	-

Firstly, the initial rate of degradation was very rapid. An average of 79% of the material degraded in 24 hours was degraded in the first six hours, 63% in the first three. Secondly, there was a clear difference in the extent of the rumen degradation of the wheat bran in week 1 compared with weeks 2 and 3. Table 3 also shows that although the extent to which the bran was degraded was different (81% digested in 24 hours compared with 64-68%), the rates of digestion were very similar if they were compared on the basis of the proportion of 24 hour degradable dry matter degraded

Figure 7:
Dry matter loss of wheat bran from dacron bag placed in the rumen of Zebu bulls fed chopped whole sugar cane(△, ▲, ○ trials 1, 2 and 3 respectively) (means of 4)



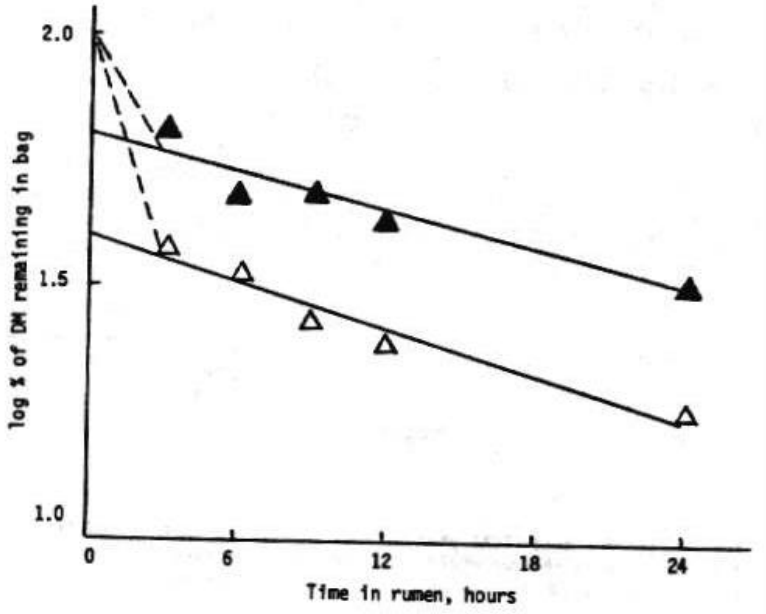
in a given time. Figure 8 shows the results for weeks 1 and 2 presented in a different way. In this figure, the dry matter remaining has been plotted on a semi-logarithmic basis with time. There is a good fit with a straight line, the regression equations (Figure 8) were:

(1) $Y = 1.60 - 0.015X$ $Seb = \pm 0.002$ (week 1)

(2) $Y = 1.80 - 0.012X$ $SEb = \pm 0.002$ (week 2)

when Y = log % dry matter remaining, and X = time in hours. The slopes do not differ significantly, but the intercepts do differ - corresponding to 40 and 63% for weeks 1 and 2 respectively. The intercepts are far removed from 2.0 (log 100), and this demonstrates the very rapid rate of disappearance in the first three hours (slopes shown by dotted lines). Mohamed and Smith (1977), who used the rumen bag technique to evaluate protein sources, interpreted this effect (rapid initial loss of material) as being the proportion which was water soluble and hence washed out

Figure 8:
Semi-logarithmic plot of dry matter of wheat bran remaining in dacron bags in the rumen of Zebu bulls fed chopped whose sugar cane (△, ▲, trials 1 and 2 respectively)



of the bags. We checked this by making a comparison between the dry matter loss of wheat bran from rumen bags soaked in water, and the dry matter loss from the bags in the rumen of animals. The results of this trial are shown in Table 4. Two bags containing wheat bran (about 10 g) were soaked in water for three hours, and six bags (two in each of three animals) were introduced into the rumens of animals on a cane diet in the usual way. The duplicate samples are in good agreement, and demonstrate that a large part of the initial loss can be soaked and washed out of the

Table 4:
The dry matter loss of wheat bran from dacron bags soaked in water or suspended in the rumen for 3 hours.

		Soaked in water	Suspended in the rumen (animal #)			
			34	114	81	
Replicate	1	36.8	52.4	50.7	58.2	
	2	35.1	52.3	51.6	55.8	
	Mean	36.1	52.4	51.2	57.0	x =53.5

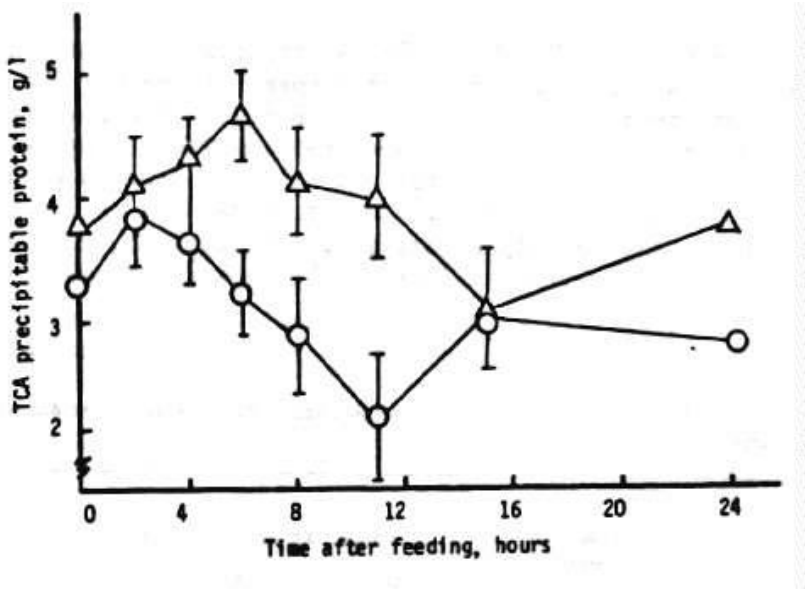
bag, The slopes of equations 1 and 2 above are in good agreement and can be used to calculate the dry matter remaining after 3 hours if this resulted from the losses due to the combination of washing material out of the bag , and the degradation at the rate given by the regression from 3 to 24 hours. Thus the dry matter remaining (Y) should be:

Log Y = log (100 - 36.1) - 3(0.015)
Y = 57.8 or 42.2% digestible

This accounts for about 80% of the dry matter loss observed (53.5% average) and suggests that about 80% of the initial loss (to 3 hours) was due to washing out, and about 20% to more rapid degradation in the first 3 hours.

Rumen Volume and Fluid Flow: These are also given by Table 1. There was no effect of wheat bran on rumen fluid volume which was about 30 lobes in all treatments. The two high levels of wheat bran were associated with greater fluid flow rates, supplementation at the higher levels (1000 and 1500 g/d) increasing flow rates above the control by 48% (P = 0.02) and 24% (P =0.15) respectively. There was thus an increase in rumen fluid turnover rate at the higher levels of wheat bran supplementation (Table 1).

Figure 9:
Trichloroacetic acid (TCA) precipitable protein in rumen fluid of Zebu bulls given chopped whole sugar cane supplemented with 0 and 0.5 (○) or 1.0 and 1.5 (△) kg/d wheat bran (means of 8 observations ± SEx)



TCA Precipitable Protein: This is shown by Table 1 and by Figure 9. Although there was an indication of a diet effect at 6, 8 and 11 hours, the high residual variation tended to obscure individual treatment effects. Therefore the data were bulked as

Control, and 500 g/d wheat bran and 1000 and 1500 g/d wheat bran as shown by Figure 9, This demonstrates that supplementation with wheat bran increased TCA precipitable protein. Since supplementation also tended to increase fluid flow rates, it is likely that the flow of protein to the abomasum was also increased. An attempt was made to calculate this by multiplying the fluid flow rate by the average TCA precipitable protein concentration. This gave flows of 75, 81, 153 and 124 ± 17 g protein/d. Clearly there are many assumptions with this. If a substantial proportion of this protein was protozoal, it may not have reached the abomasum (Weller and Pilgrim 1974). However, there were no trends in protozoal levels as measured by protozoal biomass (Table 1). TCA precipitable protein, as defined here, does not take into account any protein associated with the particles retained by the colander used for straining the rumen fluid, and thus may underestimate the flow of protein to the abomasum. Nevertheless, it does provide some evidence that supplementation with wheat bran was associated with an increase in the amount of protein made available to the animal. Whether this protein represented undegraded protein from the wheat bran, or microbial protein is also not certain. However, the fact that 80% of the wheat bran dry matter was lost from the rumen bags in the first six hours (Table 3), and that the biggest treatment differences in levels of TCA precipitable protein were from 6-11 hours implies that this was probably microbial protein. It also provides some evidence that the flow of protein to the abomasum with unsupplemented cane diets is probably low.

Conclusions

This experiment showed, in agreement with other published work cited, that judged by the parameters of pH and VFA levels, rumen fermentation on cane diets is very stable with supplementation levels of up to 35% of dietary dry matter with wheat bran. It also demonstrated that the rumen degradation of wheat bran is rapid, and that supplementation of cane diets with wheat bran increases rumen fluid turnover rates. This is probably associated with a greater flow of protein to the abomasum, much of which is likely to be microbial. The flow of protein to the abomasum of unsupplemented animals is probably low.

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