STUDIES ON DIGESTION IN DIFFERENT SECTIONS OF THE INTESTINAL TRACT OF BULLS FED SUGAR CANE/UREA WITH DIFFERENT SUPPLEMENTS[1]

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Weights and samples of digestive tract contents were obtained from bulls (4 per diet) which had received during a 2mth period ad libitum chopped whole sugar case and urea, and supplemented with either molasses, maize grain, rice polishings or cottonseed meal or given no supplement . The animals were slaughtered approximately one hr after feeding. None of the supplements appeared to affect the amount of digesta in the different organs . Data from the control diet (sugar cane/urea) indicated 86% of the total digesta and 92.4% of the total VFA were in the fore-stomachs . Only 2.7% of the digesta and 2.2% the VFA were in the caecum. pH was high (range 6.6 to 6.9) in all organs other than the abomasum (pH of 2.9 to 3.8) . Ammonia and VFA were detected in all organs of the digesta tract. Dietary supplements had no effect on the total VFA concentration in the rumen or the molar proportions of the VFA. The range was 53 to 59% for acetate, 25 to 30% for propionate and 13 to 20% for butyrate. Protozoa were found in the rumen in considerable numbers as evidenced by direct counting and measurements of protozoal biomas by packed cell volume. Major contributors to the biomass were the holotrich protozoa Isotricha intestinalia (approximately 80%) and dasytricha spp (20%) but entodim a were also present. Except for occasional animals, no protozoa could be detected in the omasum either by counting or by biomass estimation. This was true both for the large holotrichs and the smaller entodinea. The experimental results shows that in cattle fed sugar cane the rumen is the most important organ in terms of availability of energy substrate. The lack of effect of the supplements on rumen processes appears to emphasise their probable role as suppliers of essential nutrients at the level of the small intestine.

Key words: Cattle, sugar cane, digestive tract, protozoa, fermentation.

It has been postulated that the large rumen protozoa play an important role in the utilization of diets based on sugar cane (Leng and Preston 1976). There are also indications that the high content of soluble sugars in this feed depresses the digestibility of the fibrous cell wall components (Valdez and Leng 1976). For this latter reason, a considerable amount of digestible fibre may leave the rumen, and this could mean that fermentation in the lower regions of the digestive tract might be important in cattle fed sugar cane.

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The objective of this experiment was to obtain more precise information on the population of rumen protozoa and specifically to try and ascertain whether they leave the rumen because recent findings in sheep indicate the contrary (Weller and Pilgrim 1974); information was also sought on the extent of digestion in the different parts of the digestive tract, and whether this might be influenced by the amount and nature of the supplements.

Materials and Methods

Treatments and Design: Weights and samples of digestive tract contents were obtained from bulls (4 per diet) which had received during a 2 month period chopped whole sugar cane (fed ad libitum) mixed with urea and supplemented with either molasses, maize, rice polishings or cottonseed meal (table 1).

Animals: These were Zebu bulls of approximately 350 kg live weight and 2 to 3 years of age.

Slaughter Procedures: 3 hr after feeding each bull was shot with a 28 calibre Smith and Weston pistol at the transects of the horns and eyes. Immediately the body cavity was opened and the organs of the digestive tract ligated (figure 1). Each organ was separated and weighed full and empty to estimate the weight of contents. After thorough mixing of the contents of each organ (samples from the rumen, reticulum and omasum were processed first), quantities of 20 to 50 ml of fluid were squeezed by hand from the mixed contents. pH, protozoal biomass and protozoal numbers were measured immediately and 20 ml of fluid adjusted to pH 4 with 10 NH_2SO_4 and stored at -15° .

Table 1:
Dietary treatments (the aqueous urea and molasses/urea solutions were added to the chopped sugar cane at the rate of 50g/kg fresh cane)

a Urea in water (200g/kg)
B Urea/molasses (200g urea, 200g water, 600g final molasses)
C Urea/molasses plus 600g/d cottonseed meal
D Urea/molasses plus 1 kg/d rice polishings
E Urea/molasses plus 1 kg/d ground maize grain
F Urea/molasses plus 2 kg/d ground maize grain

Analyses:

Total volatile fatty acids (VFA): Concentration in rumen fluid was determined by titration following steam distillation The proportions of the VFA as acetic, propionic and butyric acids were estimated by gas liquid chromatography after extraction into ether (Valdez et al 1977). Rumen fluid (4 ml) was placed in a small stoppered tube and 0.08 ml 5% (w/v) 4 NH_2SO_4 added followed by 2 ml ether. The tube was stoppered and shaken by inverting 30 times before being placed in a freezing cabinet (- 15°). Following freezing the ether was poured into a test tube and about 50 mg anhydrous $MgSO_4$ added to absorb any residual water. After standing for 5min, 2 to 5 µl were injected into a 2 m stainless steel column (0.3 cm containing LAC-IR 296 (Burrell Corporation Pittsburgh, Pa). a Carle gas chromatograph was used with a thermal conductivity detector and hydrogen as the carrier gas. VFA proportions were calculated by reference to a chromatogram of a known mixture of acids prepared in the same way (Holdeman and Moore 1972).

Ammonia: Ammonia in rumen fluid was estimated by a modification of the indophenol method of Charney and Marback (1962). Rumen fluid (1 ml) was added to a 100 ml wide mouth flask with a lid that was sealed by a rubber liner. A small hole was drilled in the lid. A scintillation vial containing 0.5 ml 0.28 NH_2SO_4 was placed inside the flask and the lid tightly closed 1 ml 5 N NaOH was injected into the rumen fluid using a syringe and needle and the hole was closed with waxed paper. The flasks were allowed to stand at room temperature for 8 hr; water . (5 ml) was then added to the acid in the vial and 1 ml of this solution was taken for analysis according to Charney and Marback (1962). This consisted of the addition of 5ml of solution I (250mg Na-nitroprus side in 10ml H_2O; one ml of this solution then added to a solution of 5g phenol in 500ml H_2O) and 5ml of solution II (5.5g NaOH, 16 ml of 5% NaOCl made up to one litre). After 30min the colour was read in a spectrophotomer at 625 nm (Spectronic 70: Bosch and Lomb).

Recoveries of ammonia from standard solutions were 80 to 90% and a standard curve and blanks were always analysed in the same way and at the same time as samples.

Protozoa: Numbers were counted in a 0.1 mm graduated chamber under a microscope. a technique was developed for rapid assessment of protozoal biomass based on sedimentation in a hematocrit tube. 1 ml glucose solution (100 mg glucose) was placed in a centrifuge tube and 15 ml of rumen fluid added. The tube was incubated at 40° for 20 min. Much of the soluble matter in rumen contents floated to the surface because of gas production and could be removed with a pasteur pipette. The protozoa settled gradually and after 20 min the tube was highly centrifuged (500 rpm) and the rumen fluid removed to leave the protozoa in 1 ml. This was then transferred to a graduated hematocrit tube (1 ml) and incubated for 5 min at 40° . Further separation of protozoa and feed materials was achieved in the tube. The tubes were centrifuged at 1500 rpm for 1 min and protozoal packed cell volume read as a percentage of the total volume . Results are recorded as percentage of rumen fluid and are termed protozoal biomass (% rumen fluid). In the majority of analyses,

particularly where protozoa were present in large numbers, a clear demarcation between protozoa and plant material was obtained; however with small numbers of protozoa, there were difficulties in separation. Repeated analyses of samples indicated that biomass was estimated with an accuracy of + 8% when protozoal biomass was above 1%.

Results

Digesta weight and DM content The weights of digesta, and the more important fermentation parameters, for the different organs along the digestive tract, for each diet, are given in table 2. In table 3, comparisons are made between diets on a body weight basis. Figure 1 shows a diagrammatic representation of the results for digesta, pH and VFA data for the control diet(sugar cane and urea only).

a relatively high proportion of the total digesta in the whole of the tract was present in the forestomachs. In contrast, the amount of digesta in the whole of the hind tract, and particularly the caecum was low. None of the various supplements appeared to affect the amounts of digesta in the different organs . The rumen contents had a relatively high concentration of dry matter.

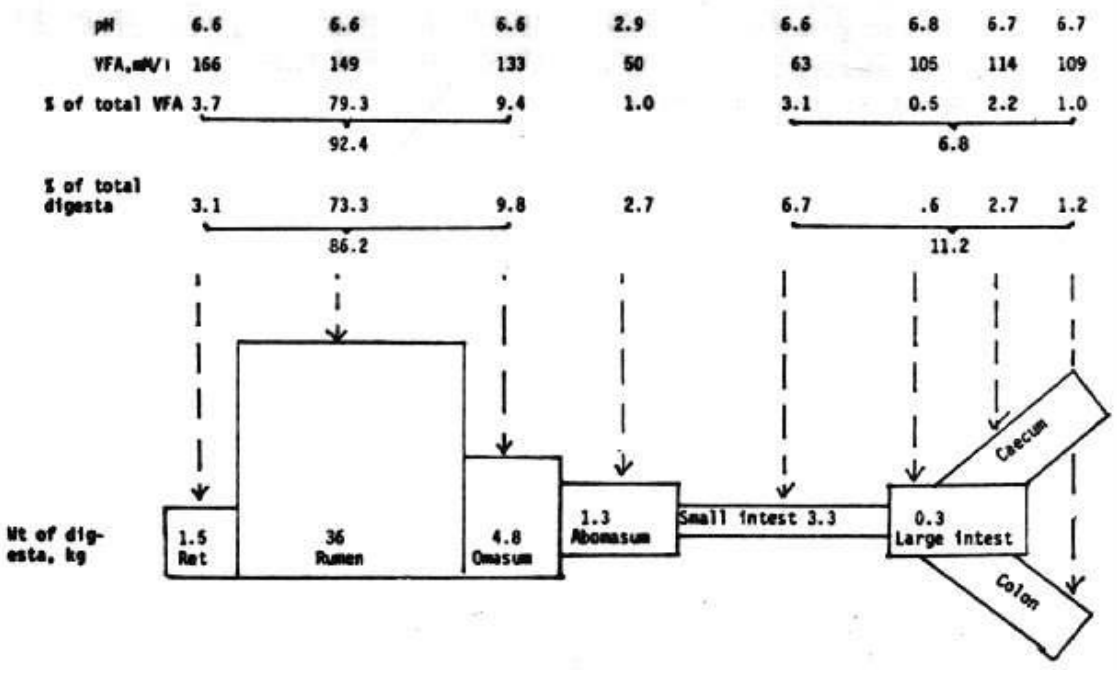

Figure 1:
Data for digesta contents, pH and VFA on the control diet of sugar cane and urea

Table 2:
Mean value for digestive tract parameters on diets containing sugar cane supplemented urea of urea/molasses and Rice polishings (4 animals/treatment)

	Reticulum	Rumen	Omasum	Abomasum	Small Intestine	Large Intestine	Caecum	Colon
Sugar cane and urea								
Wt contents, kg	1.5±.17	3±2.6	4.8±.50	1.3±.19	3.3±.52	0.03±.11	1.3±.40	.6±.27
Dry matter, %	14.3±.49	15.5±2.2	21.0±.55	9.60±.91	11.5±2.5	13.9	11.3±1.04	11.7
pH	6.60±.15	6.58±1.7	6.65±.25	2.90±.83	8.58±.14	5.78±.14	6.70±.20	6.72±.11
Total VFA, mm	166±22	149±23	133±28	50±7.3	63±13	105±19	114±10	109±12
Molar VFA, %								
C_2	58±2.8	59±4.1	67±2.0	76±3.3	85±3.0	68±2.4	72±1.6	67±2.0
C_3	26±1.7	28±2.6	26±1.7	18±2.4	10±3.4	25±2.0	21±.37	7±1.2
C_4	16±1.5	14±1.6	7±.3	6±1.3	5±.69	7±.79	7±1.4	7±1.2
NH_3, mg/100ml	26±5.6	26±5.6	15±1.8	10±3.5	29±.59	20±5.0	25±7.1	22±4.2
Sugar cane, molasses/urea and 1 kg/d of rice polishings								
Wt contents, kg	.70	47±1.8	5.9±.88	1.8±.16	3.7±.41	.40±.15	1.4±.16	1.1±.30
Dry matter, %	23.6	12±1.0	16.3±3.2	13±1.5	9.4±10.6	10.6	10±1.0	11.4
pH	6.8	6.5±.02	6.7±.10	3.4±.51	7.3±.14	72.7	6.9±.05	7.1
Total VFA, mm	115	122±25	129±20	83±24	60	107±3.0	140±49	87±6.7
Molar VFA, %								
C_2	54	53±4.5	52±10	55	-	68	65±2.5	71±.50
C_3	28	30±2.0	28±.50	28	-	24	27±1.0	23±.30
C_4	18	17±2.0	17±9.5	7	-	9	7±.50	6±.50
NH_3, mg/100ml	-	16	15	20	19	-	18	9

Table 2 (Contd):
Mean values for digestive tract parameters on diets containing sugar cane supplemented with molasses/urea alone or plus cottonseed meal (4 animals/treatment)

	Reticulum	Rumen	Omasum	Abomasum	Small Intestine	Large Intestine	Caecum	Colon
Sugar cane and molasses/urea								
Wt contents, kg	1.3-.45	54+4.6	6.1+.62	2.0+.12	4.2+.57	.22+.12	.90+.20	1.0 +.46
Dry matter, %	12.5±4.6	14.4±1.5	20.9±.90	11.1±1.2	9.8±.38	16	.14±1.7	12.8 ±1.4
pH	6.9±.19	6.6±.12	7.0±.26	3.0±.25	7.1±.13	6.8	6.9±1.2	6.8±.13
Total VFA, mm	110±19	115±7.7	77±12	42±9.5	60±8.1	73±.17	63±16	80±8.9
Molar VFA, %								
C_2	58±4.0	56±2.4	70±2.4	74±2.4	74±2.9	82±5.7	73±1.9	72±1.1
C_3	29±2.4	30±2.4	26±1.6	19±2.1	12±3.8	24±.50	21±2.3	22±1.7
C_4	13±1.6	14±.68	4±.79	7±.81	5±2.0	5±.60	6±.60	6±.89
NH_3, mg/100ml	30±12	19±3.3	50±5	18±1.8	44±4.0	28±7.7	26±3.7	21±6.5
Sugar cane, molasses/urea and 0.6kg/d of cottonseed meal								
Wt contents, kg	1.8	47±2.6	5.6±.95	1.4	1.3±2.8	-	1.3±.25	-
Dry matter, %	-	13.2±.73	17.3±1.4	6.8	7.5±.71	10.2	9.5±.48	-
pH	7.0	6.6±.09	6.8±.04	3.2	7.9	-	6.9±.06	-
Total VFA, mm	-	122±11	52±15	64	172±11	38	90	-
Molar VFA, %								
C_2	53	55±1.8	64±8.7	63	84	-	71±5.7	-
C_3	29	28±.96	27±4.0	26	11	-	24±4.4	-
C_4	18	17±.91	8±4.7	12	5	-	5±.95	-
NH_3, mg/100ml		4.8±1.4	29±10	17	20±.90	-		-

Table 2 (Contd)
Mean values for digestive tract parameters on diets containing sugar cane supplemented with urea either 1 or 2 kg/d of maize grain (4 animals/treatment)

	Reticulum	Rumen	Omasum	Abomasum	Small Intestine	Large Intestine	Caecum	Colon
Sugar cane, urea and 1 kg/d of maize grain								
Wt contents, kg	1.9±1.0	58±1.7	5.7±.81	2.1±5.3	4.2±.63	.65±.42	1.1±.13	1.4±.43
Dry matter, %	15.3±3.2	14.6±1.6	23.2±1.9	12.5±1.4	16.7±3.3	13.1±.62	10.5±.21	10.9±.78
pH	6.5±.03	6.5±.02	6.5±.17	3.8±.25	7.0±.38	6.5±.03	6.8±.08	6.8±.06
Total VFA, mm	176±46	142±25	87±10	42±4.0	55±5.0	76±12	82±13	54±19
Molar VFA, %								
C_2	54±1.4	54±9.9	69±1.5	62±5.9	68±.05	66±4.1	71±3.1	69±5.6
C_3	26±.84	26±1.3	24±.81	23±4.5	21±2.4	26±4.6	22±3.4	24±4.1
C_4	20±1.3	20±2.7	7±1.2	15±1.25	11±2.4	8±.78	7±.90	7±1.7
NH_3, mg/100ml	34±5.5	34±1.6	31±6.8	24±1.8	48±5.5	37±7.9	44±3.6	27±8.4
Sugar cane, urea and 2 kg/d of maize grain								
Wt contents, kg	1.1±.21	39±6.1	6.6±.35	1.6±.35	3.6±.77	.16±.02	2.1±.25	.30±.16
Dry matter, %	17.3±2.6	15.6±1.2	20.4±1.2	10.6±.43	7.7±.27	13.8±.1.1	10.0±.44	12.1±1.3
pH	6.5±.14	6.4±.08	6.2±.25	3.5±.24	6.8±.18	6.8±.05	6.6±.18	6.8±.12
Total VFA, mm	181±39	144±18	129±36	51±6.0	48±11	94±20	88±13	65±5.0
Molar VFA, %								
C_2	58±2.2	56±3.0	66±2.6	74±3.0	85±1.7	70±2.5	73±1.6	73±1.7
C_3	25±3.2	37±2.4	24±1.8	16±2.0	10±1.6	23±2.3	22±1.3	22±1.2
C_4	16±4.2	17±1.4	9±2.5	10±1.3	5±.55	6±.42	5±.66	5±.53
NH_3, mg/100ml	32±3.4	36±2.6	28±5.7	53±4.2	41±5.3	30±2.1	33±2.5	21±6.0

On the control diet, in which only urea was given as a supplement to the sugar cane, feed intake and the amount of digesta in the stomach, as a percentage of live weight, was less than that in animals on diets with additional supplements. Although results are reported for the contents of the small intestine, little emphasis is placed on this because there was intestinal sloughing resulting from the method of slaughter.

pH: a characteristic of sugar cane based diets is the high pH in the rumen and the data presented here confirm this. All other organs of the digestive tract, excluding the abomasum, had very similar and high values. In most conventional diets, caecum pH is higher than rumen pH, however this was not the case in the present experiment. The pH in the abomasal was within the range of reported values. There was a tendency for abomasum pH to be slightly lower for the two diets which did not contain starch or protein supplements.

Ammonia: Considerable amounts of ammonia were found in all the organs of the digestive tract. There was a fall in concentration between the rumen, omasum and abomasum indicating absorption, whereas in the small intestine ammonia levels were higher with a tendency to rise again in the caecum, probably indicating entry of urea from blood. However deamination of some amino acids may have occurred because of evidence of considerable fermentative activity even in the small intestine.

Total VFA: Since the animals were killed 3 hr after feeding when fermentation activity would be at its peak, VFA levels were generally very high in the rumen and omasum. There was evidence of considerable absorption of VFA from the rumen and the omasum. however VFA's also occurred in considerable quantities in the abomasum. Some fermentative activity appeared to take place in the small intestine since on all diets there was an increase in VFA levels between the abomasum and the small intestine. This activity may have occurred in the lower part of the small intestine since the intestines were tied at the level of the ileum. There was also considerable fermentation in the caecum although the organ was small. Of the total VFA in the whole of the digestive tract, over 90% was present in the reticulum-rumen and omasum.

VFA proportions: Dietary supplements apparently had no effect on the total VFA concentration or the proportions of the major VFA. The average proportions for the different diets are given in table 3 and show a restricted range of 53 to 59% for acetate, 25 to 30% for propionate and 13 to 20% for butyrate.

Between the rumen and omasum there was an increase in the proportion of acetate at the expense mainly of butyrate, indicating either an increase in the relative rate of acetate to butyrate production in the omasum, or a more rapid absorption of butyrate. From the omasum to the abomasum there was a further increase in the proportion of acetate on most diets. Along the rest of the digestive tract there was a tendency for further increases in acetate and decreases in propionate proportions. In the caecum the proportion of propionic acid increased to values slightly lower then those recorded in the rumen. The proportion of butyrate in the caecum was considerable lower than that in the rumen.

Table 3:
Mean values for live weight, digesta contents and rumen fermentation according to diet

	Urea/water			Urea/molasses		
	No supp	1 kg/d Maize	2 kg/d Maize	No supp	.6 kg/d cotton seed meal	1 kg/d Rice polishings
Live weight and digesta contents:						
Live wt, kg	325±.71	396±14	346±27	362±15	338±18	345±10
DM intake, % live wt	1.02	.59	2.15	1.65	-	1.83
Content of digesta,% LW						
Rumen, reticulum, omasum	I2.9^{c}	16.7^{ab}	13.4^{bc}	I7.2^{ab}	15.6^{ab}	15.3^{ab}
Caecum, large intest, colon	.76	.85	.72	.58	-	.66
Rumen fermentation						
Total VFA, mm	149	176	161	115	122	115
Molar VFA, %						
C_2	58	54	55	56	55	53
C_3	28	26	27	29	28	35
C_4	14	20	17	13	17	17
pH	6.6	6.5	6.4	6.9	6.6	6.5
NH_3,mg/100 ml	26	34	38	30	-	16

^{abc} Means without letter in common differ at P<.05

Table 4:
Estimates of protozoal population in the stomach according to biomass (packed cell volume as % rumen fluid) and direct counting methods

	Urea/water			Urea/molasses		
	No supp.	1 kg/d maize	2 kg/d maize	No supp	.6 kg/d cotton seed	1 kg/d Rice polishings
Protozoa biomass						
Reticulum	5.4±.76	10.7±9.1	7.6±4.2	2.0±.67	3.3	2.9
Rumen	4.2± 2.5	4.5±3.2	7.8±3.0	1.9±.32	2.61±.21	2.4±.35
Osasum	0.0	0.0	0.0	0.0	.46	0.0
Protozoa count, $X10^{-5}$/ml						
Reticulum						
Holotrich	3.3±.67	3.4±1.2	3.2± 2.0	1.7±.76	-	1.9
Entodinia	1.96±.39	3.5± 1.1	2.2±.34	1.9±.30	.54	.70
Rumen						
Holotrich	2.48±.76	1.7±.23	1.7±.63	1.23±.07	3.3±.48	1.3±.25
Entodinia	3.0± 1.2	4.2±1.4	2.7±.42	2.1±.69	1.1±.38	1.3±.60
Omasum						
Holotrich	0.0	0.0	0.0	0.06±.04	-18±.02	.3
Entodinia	0.0	0.0	0.0	0.6	.19±.11	.4

Rumen protozoa: a consistent finding in this experiment was high and variable biomass and counts of rumen protozoa (table 4). The holotrich protozoa isotricha intestinalis (approximately 80%) and dasytricha species (20%) were the major contributors to biomass. Except for occasional animals, no protozoa could be detected in the omasum either by counting or by biomass estimation. This was true both for the large holotrichs and the smaller entodinea. Because of the cell size of the chamber used for counting (0.1 mm depth), we have no confidence in the absolute numbers reported for holotrich protozoa however these are included in table 4 as further evidence for the lack of movement of these organisms out of the rumen in their intact form.

Discussion

The major objective of this experiment was to provide data on parameters related to digestive physiology of cattle given sugar cane based diets. Calculations indicated that the majority of the digestibly dry matter in these diets could be accounted for by the content of soluble sugars. This raised the question as to the site of digestion of the cell wall fibre and also the function of the lower digestive tract in these animals, since large quantities of potentially fermentable cell wall components apparently are delivered to the lower gut . Another important question asked in these studies was how to obtain reliable figures for the protozoal population, since point sampling through -the rumen cannula was thought to give lower than actual values (since confirmed by Minor et al 1977). The final factor was whether, or not, the protozoa were leaving the rumen in view of the reports of Weller and Pilgrim (1974) and Leng (1977, personal communication) that few protozoa were detected in the omasum of sheep.

a slaughter technique was developed and used for the following reasons: (1) he relevance of the data obtained by multiple cannulation techniques in rapidly growing animals is questionable in view of the effects on voluntary feed intake of the presence of such cannulas; such that in most studies in which re-entry cannulas have been used restricted feeding appears to be mandatory; (2) in order to obtain representative samples of digesta particularly for the protozoal studies in the rumen, it is necessary to obtain samples from mixed digesta; and (3) multiple cannulation is difficult under any circumstances, and particularly so under conditions in developing countries.

Having outlined the advantages of slaughter technique, there are nevertheless obvious limitations to this methodology which must be pointed out and taken into account: (1) the data obtained refer to a single point in time; (2) the method of slaughter in which the animals were killed by a pistol shot, results in sloughing of the small intestine (for this reason very little emphasis is placed on the data from this organ; however since it represents only a small proportion of the total digesta in the tract this is not a major difficulty). Confidence is however expressed in the main data since the killing procedure was such that the different organs were tied off within seconds of the animal being shot; the rumen and omasum contents were removed and sampled within 5 to 10 minutes of death, and determinations of pH and protozoal biomass and preservation of samples for analysis were made immediately. Care was also taken to obtain representative samples from each organ.

These studies indicate quite clearly that the rumen is the most important site of fermentation and, therefore, of energy and protein supply to the animals. Surprisingly, despite the large throughput of fibre, the caecum large intestine appears to have a limited function in these animals. To what extent breed (only Zebu were used) interacts with diet we cannot ascertain from these studies but to our knowledge no direct comparisons have been made of Zebu and European breeds of cattle in terms of the relative digestive capacity of the various organs.

Since we know very little fibre is digested within the rumen (less than 19% according to Valdez and Leng 1976), there must be appreciable fermentative capacity in the materials leaving the rumen. There is also considerable physical comminution of the fibre, to an almost colloidal consistency, which must move along the tract very rapidly. This reduction to a very small particle size, and therefore the absence of long fibres and possibly fast flow out of the rumen, could account for the apparent lack of fermentative activity in the hind gut.

The relatively high level of ammonia throughout the digestive tract was expected because of the high level of urea in the diets. High ammonia concentrations in the lower digestive tract are consistent with the concept of urea recycling (Nolan et al 1973) and fermentative activity.

The high values for rumen pH encountered in this experiment are consistent with all other findings for sugar cane diets and contrast markedly with diets based on starch where pH values are always low. The other consistent finding is the high level of total VFA in the rumen and the constant proportion of the major VFA's represented by a high propionate fermentation with low butyrate, despite the very large population of protozoa (see Gilchrist and Schwarts 1976). When large amounts of starch are given, protozoa are generally absent providing feeding is ad libitum (see Eadie and Mann 1970), whereas with ad libitum feeding of sugar cane large populations of protozoa are always obtained. It seems reasonable to suppose that since these protozoa store starch from soluble carbohydrates, this might be the mechanism whereby drops in pH are prevented leading to a more uniform availability of sustrate (VFA) to the host. Other mechanisms are obviously involved in the buffering of rumen contents but no evidence is presently available on sugar cane diets. Abomasal and small intestine function appear to be normal, however it is stressed that the pH along the tract was high and similar for all organs other than the abomasum.

The stability of rumen function was apparently unaffected by the nature of the supplements used. These ranged from molasses through to maize grain and rice polishings. This lack of effect is suggestive of minimum involvement of the supplement in rumen function on sugar cane diets.

Although no analyses were done for starch in the digesta posterior to the rumen, broken grains were observed at all levels of the digestive tract when supplements of rice polishings and maize were used. This is in line with the evidence that a considerable proportion of maize escapes rumen fermentation even on hay/grain diets (Thivend & Journet 1970).a relatively high proportion of cotton seed meal is also

known to be undegraded in the rumen (Leng 1977 unpublished data).

While protozoa probably benefit the animals by helping to even out the availability of energy substrates to the animal, they may be detrimental from the point of view of protein nutrition, since they require preformed amino acids which they apparently obtain by consumption of bacteria and feed particles leading to an obvious reduction in net synthesis of microbial protein. The fact that the protozoa apparently are retained in the rumen would lead to a further reduction in net availability of protein to the host animal. It is known that the numbers of protozoa in the rumen fluctuate both within and between days (Valdez et al 1977), suggesting that there is a turnover of protozoa in the rumen. However, the significance of this - in quantitative terms, is presently unknown and will depend on the rate of breakdown of protozoal bodies within the rumen .

Conclusions

The major conclusions from this experiment are that in cattle on sugar cane diets the rumen is the most important organ in terms of availability of energy sustrate. The high population of large protozoa on sugar cane diets is confirmed however their role in the nutrition of the animal requires much further study. The lack of effect of the supplements on rumen processes appears to emphasise their probable role as suppliers of essential nutrients at the level of the small intestine.

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