INFLUENCE OF BREWERS DRIED GRAINS ON THE RUMINAL VOLATILE FATTY ACIDS (VFA) PRODUCTION AND MILK CONSTITUENTS IN ZEBU COWS

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ABSTRACT

Four lactating White Fulani (Zebu) cows fitted with permanent rumen cannulae were fed four diets: (A) Acha hay (*Digitaria exilis* Stapf), (B) 50% acha hay plus 50% brewers dried grains (BDG), (C) 75% BDG plus 25% hay and (D) 100% BDG in a 4 x 4 latin square design. Analysis of rumen total Volatile Fatty acids (VFAs), individual VFAs, ammonia-N and pH as well as some milk constituents were carried out simultaneously. Mean ruminal pH and total VFA (mM/100ml) were 7.1, 6.2; 6.5, 8.0; 5.8, 14.9 and 5.8, 13.1 for A, B, C, and D respectively. The corresponding acetate to propionate (A/P) ratios were 4.97, 4.40, 3.20 and 3.40. The molar percent values of butyrate yielded by A and B were similar and less ($P < 0.05$) than the value for C or D. Ruminal ammonia-N (mg/100ml) ranged from 5.7 for A to 6.8 for D. Total VFA, NH_3 -N and pH of the rumen fluid were affected by time of feeding ($P < 0.05$). The correlations between ruminal pH and acetate ($r = 0.98$), pH and total VFA ($r = -0.90$), and acetate and propionate ($r = -0.75$) were significant ($P < 0.05$). Cows on treatment A (acha hay) yielded higher percent milk fat ($P < 0.05$) and lower percent milk protein than those on B, C, or D. Treatment effects on milk pH and percentages of lactose, solids-not-fat (SNF) and ash were not significant. The observed depression in milk fat of cows on treatments B, C and D in comparison with cows on treatment A was related to a decrease in rumen acetate and an increase in propionate. It was observed that the fermentation of BDG yielded acetate within limits required for efficient milk production.

Key words: Brewers grains, ruminal volatile fatty acids, zebu cows, milk.

INTRODUCTION

Experimental evidence suggests that diets of different compositions, particularly those with

high proportions of concentrate supplement have considerable effect on the pattern of fermentation in the rumen. High grain diets support lower ruminal pH, higher total VFAs and higher proportions of propionate relative to acetate and butyrate in sheep and cattle, than did forage diets (Hungate, 1966; Mba and Olatunji, 1972; Mackie *et al.*, 1978).

Changes in the end-products of digestion have been shown to alter the availability of certain metabolites necessary for maintenance and milk production and consequently influence milk composition (Hoogendoorn and Grieve, 1970). Feeding high proportion of concentrate depresses the butterfat percentage in the milk (Sutton, 1970; Oldham *et al.*, 1979). The nature of the diet could also alter the solids-not-fat (SNF) and protein content of milk (Storry and Rook, 1966).

Brewers dried grain (BDG) is a by-product of brewery industries. It is of no dietary importance to man, but could serve as sources of energy and protein to livestock. There is however some paucity of information on the pattern of ruminal fermentation when cows are fed BDG under a tropical environment. Weldy *et al.* (1964) indicated a possible depression of the acetic acid production in the rumen at high temperature. This paper, therefore reports the experiment undertaken to study simultaneously the effects of acha hay, hay plus BDG or BDG alone fed to lactating cows, on rumen fermentation and milk composition.

MATERIALS AND METHODS

Animals and their management

Four lactating White Fulani (Zebu) cows of an average liveweight of 350kg and fitted with permanent rumen cannulae were used. Each cow was kept in individual metabolic crate where there was a free access to fresh water and proprietary salt licks daily *ad libitum*.

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Plan of the Experiment and Diets

Four rations were used in the experiment: (A) Acha hay (*Digitaria exilis* Stapf), (B) 50% acha hay plus 50% BDG, (C) 75% BDG plus 25% hay and (D) 100% BDG. One lactating cow was assigned to each of the rations in a 4 x 4 Latin square design. Each ration was fed for a preliminary period of 14 days followed by a 7-day collection period. Feed was offered *ad libitum* twice daily after the morning and afternoon milkings.

Sampling of Rumen Liquor

Rumen liquor was sampled during the last 3 days of the collection period from 11.00 hrs., at hourly intervals after feeding. Samples of rumen liquor were obtained as described by Alexander, (1969), but slightly modified by Mba and Olatunji (1971). About 300ml of rumen liquor were obtained at each hourly sampling.

Milk Sampling

The cows were hand-milked daily at 08.00 and

TABLE 1: PROXIMATE COMPOSITION AND ENERGY VALUE OF HAY AND BDG

	Acha Hay	BDG
Dry Matter	94.80	90.10
Crude Protein g/100g Dm	4.40	10.60
Crude Fibre	43.80	30.60
Ether Extract	0.60	6.90
Ash	7.00	3.60
N. F. E.	39.00	28.40
Gross Energy (Kcal/g)	4.80	6.25

Analytical Procedure

Milk fat was determined by the Gerber method. Milk lactose was determined using the colorimetric method (Barnett and Tawab, 1957) as modified by Marier and Boulet (1959). Ash

TABLE 2: MEAN VALUES OF RUMINAL pH, AMMONIA-N, TOTAL AND INDIVIDUAL VFA

Rumen Parameters	D I E T			
	A	B	C	D
pH	7.08 ± 0.05 ^a	6.47 ± 0.05 ^{ab}	5.75 ± 0.04 ^b	5.80 ± 0.05 ^b
Ammonia-N (mg/100ml)	5.70 ± 0.26 ^a	6.39 ± 0.78 ^b	6.27 ± 0.32 ^{ab}	6.75 ± 0.06 ^b
Total VFA (mM/100ml)	6.18 ± 0.38 ^a	8.00 ± 0.38 ^{ab}	14.93 ± 1.52 ^c	13.05 ± 0.81 ^{bc}
Acetic Acid (Molar %)	78.29 ± 0.89 ^a	72.40 ± 0.64 ^{ab}	65.39 ± 0.48 ^b	67.86 ± 0.78 ^b
Propionic Acid (Molar %)	12.80 ± 0.29 ^a	16.43 ± 0.27 ^a	20.23 ± 0.39 ^b	20.25 ± 0.96 ^b
Butyric Acid (Molar %)	5.52 ± 0.65 ^a	5.89 ± 0.14 ^a	11.13 ± 0.47 ^b	9.98 ± 0.20 ^b
Acetate/Propionate Ratio	4.97 ± 0.14 ^a	4.42 ± 0.11 ^{ab}	3.24 ± 0.08 ^c	3.38 ± 0.20 ^{bc}

a,b,c Means in the same row with different superscripts differ (P.05). ± S.E. = Standard Error

16.00 hrs. during the collection period. The milk was stored in a deep freezer at -5°C until required for chemical analysis. However, lactose was determined from fresh samples during the collection period.

content of milk was obtained by igniting the dried milk sample in a muffle furnace at 550°C.

The A.O.A.C. (1970) method was used for the determination of proximate composition of the forage, concentrate supplements and milk

protein ($N \times 6.38$). The rumen liquor was strained through two layers of fine cotton cloth and the stained fluid was used for the determination of:

- (a) pH using the Pye pH meter with Pye-Ingold combined glassreference electrode,
- (b) Total VFAs using the AOAC (1970) method,
- (c) Individual VFAs (Mba and Olatunji, 1971),
- (d) Ruminal ammonia-N (Fawcett and Scott, 1960) as modified by Chaney and Marbach (1962). Gross energies of hay and BDG were determined with Ballistic Bomb Calorimeter.

The data were subjected to statistical analysis according to Steel and Torrie (1960).

RESULTS

The proximate composition and gross energy

TABLE 3: EFFECT OF TIME OF SAMPLING AFTER FEEDING ON RUMINAL pH, NH_3 -N, TOTAL AND INDIVIDUAL VFA

Rumen Parameters	Time (hours) after Feeding				
	1	2	3	4	5
pH	6.13 ± 0.34^a	6.26 ± 0.29^b	6.30 ± 0.30^{bc}	6.30 ± 0.30^c	6.39 ± 0.34^d
NH_3 -N (mg/100ml)	7.34 ± 0.54^a	6.35 ± 0.25^{ab}	2.26 ± 0.25^{ab}	5.86 ± 0.35^{ab}	5.48 ± 0.34^b
Total VFA (mM/100ml)	12.69 ± 2.82^a	11.44 ± 2.23^{ab}	10.63 ± 2.19^{bc}	9.66 ± 1.89^{cd}	8.28 ± 1.26^d
Acetic Acid (Molar %)	68.91 ± 2.78	70.06 ± 2.54	71.11 ± 2.73	71.32 ± 3.33	72.73 ± 3.08
Propionic Acid (Molar %)	17.61 ± 0.85	17.58 ± 0.93	18.31 ± 1.52	18.51 ± 1.43	18.95 ± 1.62
Butyric Acid (Molar %)	8.71 ± 1.12	8.19 ± 1.19	8.52 ± 1.37	8.35 ± 1.89	7.37 ± 1.40

^{a,b,c} Means in the same row with different superscripts differ ($P < 0.05$).

values of the hay and BDG are shown in Table 1. The hay was low in crude protein content. The hay and BDG contained 43.8 and 30.6% crude fibre respectively. The gross energy value of the hay was 4.8 Kcal/g DM.

The effects of the dietary treatments on rumen pH, ammonia-N, total and individual VFAs are presented in Table 2. Animals on treatments A and B produced significantly higher pH, molar percent acetate and acetate to propionate (A/P) values than either C or D. Cows on treatments C and D yielded higher molar percent values propionate and butyrate than those on either A or B. The A/P values were 4.97, 4.40, 3.20, and 3.30 for animals on treatments A, B, C and D respectively.

The effect of diet on ruminal ammonia-N production was significant ($P < 0.05$). Treatment A (hay) resulted in the lowest mean value (5.7mg/100ml rumen fluid) of ammonia-N. The corresponding values for cows fed hay increased to 6.4, 6.3 and 6.8 for cows fed treatments B, C and D respectively.

Time of sampling on the molar percents of acetic, propionic and butyric acids was not significant. However, the molar proportions of acetate and propionate tended to increase slightly with time of feeding (Table 3).

The ruminal ammonia-N (mg/100l) increased steadily from 1 hour to 5 hours after feeding. Variations among values obtained at 1, 2, 3 and 4 hours after feeding, were not significant. However, the mean value at 1 hour was significantly higher ($P < 0.05$) than that at 5 hours.

The regression equations, standard errors (S.E) and correlation coefficients (r) obtained from the various combinations of rumen pH, total VFA, individual VFAs and ammonia-N are shown in Table 4. Significant but positive correlations ($P < 0.01$) were obtained between pH and acetic acid ($r = 0.98$), pH and acetic/propionic acid ratio ($r = 0.90$). However, ruminal pH showed significant ($P < 0.01$) and negative correlations ($r = -0.90$) with total VFA and propionic acid ($r = -0.81$). The relationship between ruminal pH and ammonia-N ($r = -0.52$) was not significant. Ammonia-N was positively correlated with propionic acid.

The effects of dietary treatments on some milk constituents are presented in Table 5. Dietary treatment effects on milk pH, lactose, SNF and

TABLE 4: REGRESSION EQUATIONS, STANDARD ERRORS (SE), AND CORRELATION COEFFICIENTS (r) FOR RUMINAL PH, NH₃-N, TOTAL AND INDIVIDUAL VFA.

X	Y	Equations	± SE	r
pH	V FA (mM/100ml)	$Y = 51.32 - 6.50 X$	0.92	-0.90**
pH	Acetic acid (molar %)	$Y = 14.27 + 9.04 X$	1.17	+0.98**
pH	Propionic acid (molar %)	$Y = 39.44 - 3.39 X$	0.53	-0.81**
pH	Acetic/propionic ratio	$Y = -3.81 + 1.24 X$	0.18	+0.90**
pH	Ammonia-N (mg/100ml)	$Y = 10.50 - 0.68 X$	0.20	-0.52 ^{ns}
Ammonia-N (mg/100ml)	Acetic acid (molar %)	$Y = 87.14 - 2.58 X$	1.17	-0.45*
Ammonia-N (mg/100ml)	Propionic acid (Molar %)	$Y = 5.78 - 1.84 X$	0.99	+0.39 ^{ns}
Ammonia-N (Mg/100ml)	Butyric acid (Molar%)	$Y = 2.91 + 0.85 X$	0.57	+0.30 ^{ns}
Ammonia-N (mg/100ml)	VFA (mM/100ml)	$Y = 1.93 + 1.99 X$	0.92	+0.44*
Acetic Acid (molar %)	Propionic acid (molar %)	$Y = 42.10 + 0.34 X$	0.53	-0.75*

* = (P < 0.05) ** = (P < 0.01) ns = Not significant (P > 0.05)

ash, were not significant. Treatment A fed cows recorded the lowest milk protein value (3.7%) and the differences observed were significant (P < 0.05). Furthermore, treatment A fed cows yielded significant higher (P < 0.05) percent milk fat and total solids than any cow on treatments B, C or D with values which were similar, as the variations observed were not significant.

DISCUSSION

The mean rumen pH values obtained at hourly intervals after feeding clearly showed minor increases with time after feeding. Similar observations had been reported (Mba and Olatunji, 1972; Murdock *et al.*, 1981; Davis *et al.*, 1983). The present mean rumen pH value of 5.8 for cows on treatment C or D was close to the value 6.2 obtained when 20 - 30% pressed BDG were included in dairy cattle ration (Davis *et al.*, 1983). The ruminal pH values were related to the crude fibre content of the diets. The hay ration (Treatment A) favoured higher pH values. Thus, the higher the fibre content of the ration, the higher pH values of the rumen fluid as reported else-

where (Bailey, 1961; Mba and Olatunji, 1972; Kwan *et al.*, 1977; Davis *et al.*, 1983). Bailey (1961) noted that rumen pH levels by maintaining a copious flow of saliva to the rumen.

In general, the rumen pH seemed to increase as the total VFA in the rumen decreased. A number of reports (Hibbs *et al.*, 1956; Briggs *et al.*, 1957) demonstrated that pH was inversely proportional to VFA concentrations in the rumen. The highest total VFA and ammonia-N production in this study was recorded 1 hour after feeding as reported by Pant and Roy (1971). A gradual decrease in the concentration of both ammonia-N and total VFA with time after feeding is an evidence of absorption and or utilization by the ruminal microorganisms.

Fairly high molar proportions of ruminal acetic acid were recorded for all diets. The hay (treatment A) yielded highest molar percent acetic acid, which decreased with the levels of BDG fed to the cows. Thus, the reduction in acetate production varied with the concentration of readily fermentable carbohydrate avail-

TABLE 5: MILK COMPOSITION OF FISTULATED COWS PLACED ON DIETARY TREATMENTS

Rumen Parameters	D i e t s			
	A	B	C	D
pH	6.47 ± 0.16	6.62 ± 0.17	6.43 ± 0.09	6.46 ± 0.12
Protein (N x 6.38)%	3.76 ± 0.15 ^a	4.23 ± 0.09 ^b	4.27 ± 0.14 ^b	4.33 ± 0.07 ^b
Fat %	4.49 ± 0.18 ^a	3.30 ± 0.08 ^b	3.02 ± 0.95 ^b	3.10 ± 0.11 ^b
Lactose %	4.41 ± 0.11	4.85 ± 0.07	4.95 ± 0.08	4.91 ± 0.06
Ash %	0.69 ± 0.002	0.6 ± 0.001	0.67 ± 0.002	0.63 ± 0.002
Total Solid %	13.00 ± 0.82	12.37 ± 0.97	11.81 ± 0.48	12.32 ± 0.79
Solids-not-Fat %	8.54 ± 0.80	9.09 ± 0.93	8.93 ± 0.45	9.15 ± 0.81

^{a,b,c} Means in the same row with different superscripts differ ($P < 0.05$)

able in the diets. This lowering of acetate in forages, when supplemented with concentrates is in agreement with similar reports (Franks *et al.*, 1972; Mba and Olatunji, 1972; Mba *et al.*, 1972; Davis *et al.*, 1983). The molar proportions of 65 and 68% ruminal acetate yielded by animals on treatments C and D respectively were within the limits suggested by Elliot and Loosli (1959) for efficient milk production. The present molar proportions of propionate increased as the proportion of BDG in the diets increased. The general observation in this study was that those dietary treatments which favoured higher molar concentration of propionate, also depressed the molar concentration of acetate. This observation agrees with other reports in literature (Cressman *et al.*, 1980; Murdock *et al.*, 1981; Folman *et al.*, 1981; Davis *et al.*, 1983). The molar percent butyrate increased from 5.5 for animals on treatment A (hay) to 10 and 11% for those on D and C respectively (Table 2).

This and other studies (Mba *et al.*, 1972; Mackie *et al.*, 1978; Folman *et al.*, 1981; Davis *et al.*, 1983) depicted the molar proportions of butyrate in the rumen as the lowest. It is however established that the measurement of butyrate in the rumen is complicated by the fact that it is actively metabolized by the rumen epithelia (Armstrong and Blaxter, 1957). The present acetate to propionate ratio showed a high value of 4.9 for animals fed hay (Treatment A). The lowest ratio of 3.2 and 3.4 for animals fed hay (Treatment A). The lowest ratio of 3.2 and 3.4 were obtained for cows fed diets C and D respectively. High acetate to propionate ratio was peculiar to fibrous feeds. Several workers have reported that increasing the percent of con-

centrate in the diets resulted in a narrower acetate to propionate ratios (Thompson *et al.*, 1965; Ghorban *et al.*, 1966; Olatunji, 1974) as observed in this study.

The yield of ammonia-N by cows fed hay was lower than the values for other treatments. The present ammonia-N production increased progressively with increasing percent crude protein content of the diets. This is in agreement with other reports, which showed that the higher the quantities of protein consumed the higher the ruminal ammoni-N content (Polan *et al.*, 1976; Kwan *et al.*, 1977; Cressman *et al.*, 1980). In this study, there was a rapid build-up of ruminal ammonia-N in the first sampling followed by a decline with time as observed (McDonald, 1952 and Murdock *et al.*, 1981). The BDG based diets (treatments C and D) yielded significantly higher ($P.05$) percent milk protein than either A or B. This could probably be due to the high crude protein content of BDG. A number of workers reported that milk protein tended to increase with increase in the crude protein and energy content of the diets (Hoor-gendoorn and Grieve, 1970; Mba *et al.*, 1972; Barney *et al.*, 1981; Folman *et al.*, 1981). It has also been shown that the proteins of BDG are highly insoluble and resistant to ruminal degradation (Satter and Whitlow, 1977; Hergen *et al.*, 1979). It would therefore be expected that most of the proteins of BDG, by-passed the rumen and were digested in the lower tract resulting in a more efficient protein utilization. The present milk fat percent was significantly higher for the cows fed hay (A) than the other treatment diets. A decrease in milk fat percent observed for cows fed treatments B, C and D

conincided with a decrease in rumen acetate and an increase in propionate while cows were on these treatments. This is in linr with other reports (Sulton, 1970; Mba *et al.*, 1972; Hoogen-doorn and Grieve, 1974).

In conclusion, the results of the present study indicated that the fermentation of BDG in the rumen produced acetate within the limits required for efficient milk production.

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