STUDIES IN FIBRE DIGESTION AND PASSAGE RATE OF LIQUID AND SOLID IN CATTLE AND BUFFALOES

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Summary

Rumen liquor characteristics and disappearance rate of dry matter were studied in Kedah-Kelantan cattle and swamp buffaloes fed grass or rice straw-based diet. Cobalt-EDTA and chromium mordanted fibres prepared from the faecal material were used to determine the liquid and solid particles movement in both animal species fed with rice straw. Swamp buffaloes showed a more intense rumen fermentation activity than Kedah-Kelantan cattle when both species were fed straw-based diet. The buffaloes also demonstrated faster rates of grass and straw degradation in situ. The fluid outflow rate from the rumen of buffalo (1.06 ± 0.19 l/h) was observed to be slower than that of cattle (1.55 ± 0.01 l/h). No significant differences between cattle and buffaloes were observed in rumen fluid volume and passage rate of small particles from the rumen.

(**Key Words**: Fermentation, Feed Degradation, Rumen Volume, Passage Rate, Cattle, Buffaloes)

Introduction

One of the constraints in ruminant production in Malaysia is the lack of grazing areas as most of the agricultural land are planted with cash crops like rice, cocoa, oil palm and rubber. As Malaysia produces more than 5 million tonnes of agricultural by-products annually, one useful way of exploiting these by-products is to utilize them as animal feeds, in particular, for ruminants. Palm kernel cake, a meal produced after the oil is extracted from the kernel of the oil palm fruit (*Elaeis guineensis*), has been successfully used as a basal feed material for feedlot cattle and buffalo productions (Hutagalung and Mahyuddin, 1985; Mak et al., 1985, 1986). The palm press fibre (PPF), produced after the mesocarp of the oil palm fruit is pressed for oil extraction, could be an inexpensive carbohydrate source, but is poorly degraded in the rumen. However, appropriate methods could be developed to improve its digestibility. The use of rice straw (*Oryza sativa*) as feed material is also limited because of its low digestibility and poor protein (about 4%) content.

Before feeding strategies with agricultural by-products could be adopted successfully, basic information on the digestive physiology and rumen functions of the indigenous animals viz. the swamp buffaloes (*Bubalus bubalis*) and the Kedah-Kelantan (KK) cattle (*Bos indicus*) fed highly fibrous diet is required.

This paper reports the studies in rumen fermentation and feed degradation, rumen fluid volume and outflow rates, passage rate of small particles in KK cattle and swamp buffaloes fed grass or rice straw.

Materials and Methods

Animals

Four KK cattle (mean liveweight 105 ± 6 kg) and 4 swamp buffaloes (mean liveweight 157 ± 10 kg), all male, 1½ years old were each fitted with a rumen cannulae and kept in separate pens with individual feeding trough and drinking water.

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Experiment 1 — Rumen Fermentation and Feed Degradation

Rumen fermentation and feed degradation studies were conducted with animals given 2 types of diets. The diets were chopped guinea grass (*Panicum maximum*) at late maturity and unchopped rice straw (*Oryza sativa*) with or without molasses supplements. The feeds were offered 3 times daily *ad libitum*. Each animal had free access to a cobalt-mineralized salt block.

The animals were fed guinea grass only for 3 weeks and the experiments were conducted on the fourth week. The diet was then changed slowly by mixing unchopped rice straw + molasses with grass and after an adaptation period of 10 days, 2 animals of each species were fed either rice straw alone, or rice straw + molasses (70:30% DM) for 3 weeks. This was followed by a week of experiments and the diets were immediately crossed-over and maintained for a period of 3 weeks before the experiments were repeated on the fourth week.

In the rumen fermentation study, rumen liquor was sampled at different time intervals for 24 hours in 2 consecutive days. A sampling probe covered with two layers of nylon materials was used to withdraw liquid samples from the ventral section of the rumen. The samples were immediately determined for pH and then acidified and kept frozen (−15°C). They were later centrifuged and analysed for total NH_3 and volatile fatty acids (VFA). The methods for NH_3 and VFA analyses were similar to that given by Abdullah (1989).

Degradation of guinea grass and straw was studied using the method described by Ørskov et al. (1980). Samples (dried and ground to 2 mm) were incubated in nylon bags (mesh size 44 μm) in the rumen for 8, 24, 32, 48, 56 and 72 h. The experiment was conducted when the animals were fed either grass or straw-based diet. Degradation rate, c (/h) was calculated from the equation $p = a + b(1-e^{-ct})$ (Ørskov et al., 1980).

Experiment 2 — Rumen Fluid Volume and Solid Outflow Rates

Rumen fluid volume and passage rates of small particles were determined when the animals were fed unchopped rice straw. Cobalt-EDTA was used as the fluid marker while Cr-mordanted faecal material (sieved through 1.4 mm screen) was used as the particulate marker. Both markers were prepared according to the method described by Uden et al. (1980). The rumen was dosed once with both markers at 6 mg Co and 13 mg Cr per kg body weight. Rumen contents consisting of liquid and small solids were sampled at 3 ventral locations, i.e., from the middle, the right and left and composited. The samples were then sieved through 1.4 mm screen into plastic bags and kept frozen (−15°C) until used. Sampling was done twice within the first 1½ h, then at 2-hourly intervals for the next 6 h and thereafter at 6-hourly intervals for 2 days after dose. Liquid and solid samples were analysed for Co and Cr by atomic absorption spectrophotometry.

The rumen fluid volume, and liquid outflow rates were calculated by regression of the natural logarithm of Co concentration on time. The pool size and outflow rate of small particles were calculated similarly.

Statistical Analysis

Two-way analysis of variance or student's-test was used to compare means between species.

Results

Fermentation characteristics of rumen liquor for cattle and buffaloes fed guinea grass and straw-based diets are shown in table 1. With guinea grass diet, only rumen liquor NH_3 was significantly different between species, being higher in buffaloes than in cattle. With straw-based diet, rumen liquor pH was significantly lower and NH_3 and total VFA concentrations were significantly higher in buffaloes than in cattle.

Molar proportions of acetate, propionate and butyrate did not differ between species in both grass and straw fed animals (table 2).

Total concentrations of VFA (table 3) were higher in animals fed straw (102 ± 1.1 mmol/l) than in animals fed straw + molasses (81.5 ± 1.2 mmol/l). Molasses supplementation also reduced acetate production in animals fed straw from 75.6 ± 0.1% to 65.0 ± 0.4%, but increased butyrate production from 5.2 ± 0.03% to 13.8 ± 0.3%.

Tables 4 and 5 show the % DM loss at 48 h and the degradation rates (/h) of guinea grass and straw, respectively, in cattle and buffaloes. It was observed that % DM loss of guinea grass

TABLE 1. RUMEN LIQUOR pH, TOTAL AMMONIA AND VFA CONCENTRATIONS OF CATTLE AND BUFFALOES FED GUINEA GRASS OR STRAW-BASED DIETS

Parameters	Guinea grass		Straw-based diets	
	Cattle	Buffaloes	Cattle	Buffaloes
pH	6.54 ± 0.04	6.59 ± 0.04	6.82 ± 0.02	6.49 ± 0.02
NH_3 mg N/l	58.6 ± 1.6	91.8 ± 2.2	35.5 ± 0.8	40.0 ± 0.8
VFA mmol/l	94.1 ± 2.0	96.4 ± 1.3	85.5 ± 1.6	98.0 ± 2.2

Guinea grass diet: only rumen NH_3 was significantly ($p < 0.01$) different between the two species. Each value is a mean ± S.E. of 38 samples.

Straw-based diet: Rumen pH, NH_3 and VFA were significantly ($p < 0.05$) different between the two species. Each value is a mean ± S.E. of 80 samples.

TABLE 2. MOLAR PROPORTIONS OF ACETATE, PROPIONATE AND BUTYRATE IN CATTLE AND BUFFALOES FED GRASS OR STRAW-BASED DIETS.

Molar %	Guinea grass		Straw-based diets	
	Cattle	Buffaloes	Cattle	Buffaloes
Acetate	72.0 ± 0.2	74.5 ± 0.2	72.6 ± 0.6	71.8 ± 1.0
Propionate	18.0 ± 0.2	17.0 ± 0.1	17.7 ± 0.1	17.7 ± 0.2
Butyrate	8.1 ± 0.2	7.0 ± 0.2	9.3 ± 1.0	8.3 ± 0.8

No significant difference between species was observed in both diets. Each value is a mean ± S.E. of 38 and 80 samples for grass and straw diets, respectively. The other acids (isobutyrate, isovalerate and valerate) constituted less than 5% of the total acids.

TABLE 3. TOTAL VFA AND MOLAR PROPORTIONS OF ACETATE, PROPIONATE AND BUTYRATE OF CATTLE AND BUFFALOES FED STRAW OR STRAW + MOLASSES

Parameters	Straw	Straw + molasses
Total VFA (mmol/l)	102.0 ± 1.1[a]	81.5 ± 1.2[b]
Molar %:		
Acetate	76.6 ± 0.1[a]	65.0 ± 0.4[b]
Propionate	17.3 ± 0.1[a]	18.2 ± 0.1[a]
Butyrate	5.2 ± 0.03[a]	13.8 ± 0.30[b]

Each value is a mean ± S.E. of 40 samples.

Means with different superscripts in the same row are significantly different ($p < 0.001$). The other acids (isobutyrate, isovalerate and valerate) constituted less than 5% of the total acids.

TABLE 4. PERCENT (%) DRY MATTER (DM) LOSS AT 48 HOUR AND DEGRADATION RATES OF GUINEA GRASS

Animal species	DM loss (%)	Degradation rate (/h)
Cattle	54.0 ± 0.6	0.036 ± 0.002
Buffaloes	56.2 ± 0.6	0.048 ± 0.004
Significance* (species)	$p < 0.001$	$p < 0.05$

* % DM loss was compared between species by two-way analysis of variance (% loss and sampling times as sources of variation), while degradation rate was compared by t-test. Each value is a mean ± S.E. of 8 samples.

and rice straw was significantly higher in buffaloes than in cattle. The degradation rates of both feed materials were also faster in the rumen of buffaloes than in the rumen of cattle. Molasses supplementation was found to reduce straw degradation significantly in both animal species (table 5).

As shown in table 6, both cattle and buffaloes showed similar rumen fluid valumes. Fluid outflow rate from the rumen was significantly slower in the buffaloes (1.06 ± 0.19 l/h) than in the cattle

TABLE 5. PERCENT (%) DM LOSS AT 48 HOUR AND DEGRADATION RATES OF RICE STRAW IN ANIMALS FED STRAW OR STRAW + MOLASSES

Animal species	Straw		Straw + molasses	
	DM loss (%)	Degradation rate (/h)	DM loss (%)	Degradation rate (/h)
Cattle	43.9 ± 1.3[a]	0.010 ± 0.002	35.4 ± 2.5[b]	0.009 ± 0.001
Buffaloes	47.0 ± 2.9[a]	0.021 ± 0.003	39.5 ± 3.4[b]	0.014 ± 0.004
Significance* (species)	$p < 0.01$	$p < 0.05$	$p < 0.01$	NS

Means of % DM loss with different superscripts in the same row are significantly different ($p < 0.001$). Degradation rates between diets are not significantly different.

* % DM loss was compared between species or diets by two-way analysis of variance (% loss and sampling times as sources of variation), while degradation rate was compared by t-test.

Each value is a mean ± S.E. of 8 samples.

TABLE 6. RUMEN FLUID VOLUME, FLUID OUTFLOW RATES, POOL SIZE AND OUTFLOW RATES OF SMALL PARTICLES IN CATTLE AND BUFFALOES

Parameters	Cattle	Buffaloes
Fluid volume (l/100 kg LW)	27.0 ± 2.7[a]	25.8 ± 1.0[a]
Fluid outflow rate (l/h)	1.55 ± 0.01[a]	1.06 ± 0.19[b]
Rumen fluid dilution rate (%/h)	5.43 ± 0.14[a]	2.70 ± 0.07[b]
MRT of fluid (h)	18.5 ± 0.5[a]	36.9 ± 1.2[b]
Pool size of SP (kg DM)	2.51 ± 0.40[a]	2.49 ± 0.06[a]
Outflow rate of SP (g DM/h)	75.3 ± 5.4[a]	69.4 ± 17.4[a]
MRT of SP (h)	33.8 ± 3.6[a]	41.2 ± 9.7[a]

LW: liveweight; SP: small particles

Means with different superscripts in the same row are significantly different ($p < 0.05$).

(1.55 ± 0.01 l/h) and consequently, lower rumen fluid dilution rate was observed in the former. Small particle pool size was similar between cattle and buffaloes, and although the outflow rate of small particles in buffaloes was slower than in cattle, the difference was not significant.

Discussion

The results indicate a higher fermentation activity in buffaloes. The higher rumen ammonia concentration in buffaloes could provide a better rumen environment to support microbial growth and activity. Low levels of rumen ammonia may limit microbial growth and reduce fibre digestion in cattle. This is indicated by the higher percent DM loss and faster rate of degradation in buffaloes than in cattle. However, the low levels of rumen ammonia in these animals when compared to the recommended values of 150-200 mg N/l (Leng and Nolan, 1984) would still be insufficient for maximum microbial activity.

The VFA molar proportions of either grass or straw diets were as expected with any roughage diet producing high acetate and low propionate and butyrate. The molar proportions showed inappropriate balance of nutrients in the products of digestion with high energy (acetic acid) and low glucogenic precursor (propionic acid) in both cattle and buffaloes. This reflected the low quality of the diets. The guinea grass and straw used had a high cell wall component (NDF = 80%) and low N content (1.2 and 0.7%, respectively).

The inclusion of molasses in the straw diet only increased butyrate production with a concomittent decrease in acetate production. High butyrate has been a known feature with molasses feeding in cattle and sheep (Marty and

Preston, 1970; Abdullah, 1980). High cellulolytic activity is associated with high acetate (and methane) production. Hence, a decrease in acetate production also indicated a lowering of cellulolytic activity in animals fed straw + molasses. Depressed fibre digestion in the presence of readily fermentable carbohydrates is usually observed with fibres of low digestibility (Dixon, 1986).

The different fluid outflow rates indicate differences in fluid movement in the two species. Slower fluid outflow rate in the buffalo would be an advantage as microbes in the fluid compartment are those that are in transit between digesta particles and slower outflow rate would mean lower rate of washing them out of the rumen. There was no indication of a significant difference in pool size and rate of passage of small particles between cattle and buffaloes. Kennedy et al. (1987) also reported comparable passage rate constants of particulate matter between cattle and buffalo when the animals were fed straw : leucaena diet.

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