

FERMENTATION PATTERNS AND DIET UTILIZATION BY CATTLE, SHEEP AND GOATS GIVEN GRAIN OR MOLASSES BASED DIETS

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SUMMARY

Cattle, sheep and goats were offered diets *ad libitum* in which either sorghum grain or molasses was the major energy source. All species consumed more grain dry matter (DM) (45-47 g/kg^{0.9}.day) and had higher liveweight gains (6.3-6.5 g/kg^{0.9}.day) than when fed molasses diets (38-40 gDM/kg^{0.9}.day and 3.1-3.3 g/kg^{0.9}.day respectively). There were no significant differences between species in DM digestibility (grain 70.1-71.2%, molasses 52.0-56.5%) and apparent digestibility of nitrogen (ADN) (grain 84.1-92.0%, molasses 85.3-89.9%). Grain DM digestibility was significantly ($P < 0.05$) higher than that for molasses, but ADN was similar for both diets. The N balance and proportion of ADN retained was significantly ($P < 0.05$) higher for all species on the grain diet compared with the molasses diet, and cattle had higher N balances and efficiencies of N use than sheep and goats given the same diet.

Sheep had significantly ($P < 0.05$) lower rumen ammonia concentrations than cattle and goats on both diets. Cattle had lower acetic acid and higher butyric acid concentrations in rumen fluid than sheep and goats on both diets, and lower propionic acid concentrations when fed molasses. It was concluded that sheep and goats cannot be used as a model for cattle in concentrate feeding trials.

Keywords: cattle, sheep, goats, molasses, grain, utilization.

INTRODUCTION

Comparative studies of sheep and cattle given Buffel grass of different quality have shown that cattle will voluntarily consume more feed, and digest lower quality feeds better than sheep (Playne 1970). Sheep given legume forages have been shown to digest more cell wall components and less nitrogen in the rumen than do cattle given the same feed (Hogan and Weston 1967). Studies with sheep and goats generally show that goats digest low quality diets (low protein, high fibre) to a greater extent than sheep (Devendra 1975; Wilson 1977; Doyle and Egan 1980; Watson and Norton 1982). However, less is known about the comparative digestion and utilization of high quality (concentrate) diets by cattle, sheep and goats. The following experiment was designed to compare the digestion and utilization of 2 concentrate diets (sorghum grain and molasses) by cattle, sheep and goats with a view to determining whether recommendations from feeding trials with small ruminants can be applied to cattle.

MATERIALS AND METHODS

Animals and their management

Eight Border-Leicester x Merino sheep (4 male castrates, 4 females), 8 Australian feral goats (4 males, 4 females) and 8 Hereford steers were used. Initial liveweight range for each group were: sheep, 19-23 kg; goats 19.5-24 kg; and cattle 259-310 kg. All animals were drenched with oxfendazole (Systamex, Wellcome Australia) on entry to metabolism cages where they stayed for the duration of the trial (4 weeks adaptation, 10 weeks measurement).

Diet composition and feeding procedures

Two diets were used, 1 with molasses as the major energy source and the other with sorghum grain. Water was freely available at all times. The chemical composition of the dietary ingredients used and composition of diets are given in Table 1. The diets were formulated to be equivalent in crude protein (155 g/kg dry matter (DM)), digestible energy (13.3 MJ/kg DM) and acid detergent fibre (125 g ADF/kg DM). All animals were offered diets *ad libitum* (20% excess of previous days intake) and were fed once daily each morning.

Experimental design, measurements and sampling procedures

A factorial experiment used 3 species (cattle, sheep, goats) x 2 diets (molasses, grain) x 8 animals per treatment. Feed intakes and liveweight changes of all animals were recorded at weekly and 3 weekly intervals respectively. Diet digestibility and nitrogen (N) utilization was measured over 7 days during the fifth week of the experimental period. During this period feed intake, faecal output and urinary excretions were recorded daily, sub-sampled (10%) and bulked for each animal. Prior to the morning feed, rumen

Table 1. Composition of ingredients (g/kg as fed) and chemical components (g/kg dry matter) of molasses and sorghum grain diets

Ingredients	Diet composition (as fed)		Dry Matter (%)	Chemical components	
	Sorghum	Molasses		Nitrogen	ADF
Sorghum grain	700	0	88.9	17.4	66
Molasses	0	500	86.7	1.0	0
Sunflower meal	197	190	91.0	55.2	225
Pangola hay	75	253	90.6	10.2	347
Urea	0	23	100	466.6	0
Minerals ^A	28	34	100	0	0

^AComposition of mixture added (g/kg DM) Ca - 128, P - 72, NaCl - 4.5, (mg/kg DM) Co - 200, Cu - 20, Fe - 400, Mn - 52, I - 120, Zn - 240, S - 20.

fluid samples were collected by stomach tube, with 1 portion of strained acidified (pH 3) sample being stored at 4°C for ammonia analysis, and another portion (4 mL) being mixed with 1 mL of metaphosphoric acid (25 % w/v) containing iso-caproic acid (12 mg/mL) as an internal standard, and stored at -20°C for volatile fatty acid (VFA) analysis.

Analytical and statistical methods

Dry matter of feed, feed refusals and faeces was determined by oven drying at 60°C for 48 hours while ash was determined by incineration (3 hours at 550°C). The N content of feed, feed refusals, faeces and urine was determined by distillation following Kjeldhal digestion (AOAC 1980). Rumen ammonia concentrations were determined by steam distillation and titration with 0.01 M hydrochloric acid. Concentrations and molar proportions of VFAs in rumen fluid were determined by gas liquid chromatography (Hewlett Packard 5830 A).

The effects of diet and species were analysed by analysis of variance as a 2 x 3 factorial with 8 animals per treatment. Within treatment effects of sex (sheep and goats) were analysed separately, and differences noted in the text. Significance was tested by least significant differences (Steel and Torrie 1960).

RESULTS

Effects of diet and species on dry matter intake and Ziveweight gain

After scaling for differences in body weight, there were no significant ($P < 0.05$) differences between species in DM intakes, DM digestibilities, liveweight gains and feed conversion efficiencies, but all species given grain had significantly ($P < 0.05$) greater feed conversion efficiencies than those given molasses (Table 2). Bucks given grain had significantly ($P < 0.05$) higher liveweight gains (7.1 g/kg^{0.9}.day) than does (5.3 g/kg^{0.9}.day), but no similar differences were found between castrate and female sheep.

Effect of diet on the utilization of nitrogen in cattle, sheep and goats

Daily N intake, faecal excretion and N digestibility was not significantly different between species given either molasses or grain diets. However, the amount of nitrogen retained was significantly ($P < 0.05$) higher in cattle than in sheep and goats given the same diets. Animals given the grain diet excreted less N in urine and retained more N than did those given the molasses diet (Table 2). Bucks given the grain diet had significantly ($P < 0.05$) lower urinary N and higher N balances in comparison with does given the same diet.

Effect of diet on VFA and ammonia concentrations in rumen fluid of cattle, sheep and goats

The concentrations of VFA and ammonia in the rumen fluid of cattle, sheep and goats given either grain or molasses diets are given in Table 2. Sheep given either sorghum or molasses diets had significantly ($P < 0.05$) lower ammonia concentrations in the rumen fluid than cattle or goats. Bucks fed the grain diet had significantly ($P < 0.05$) higher rumen ammonia (323 mg N/L) than did does (205 mg N/L). Cattle fed the grain diet exhibited significantly ($P < 0.05$) higher total VFA and proportions of acetate ($P < 0.05$) in the rumen fluid than did those fed the molasses diet. Cattle given the molasses diet

Table 2. Mean values (n = 8) for DM intake, liveweight gain, urinary N and N balance (mg/kg^{0.9}.day), DM digestibility, N digestibility (%) and % ADN retained (N balance/(N intake - faecal N)*100), concentrations of ammonia (mg N/L) and volatile fatty acids (VFA)(mmol/L and molar %) in rumen fluid of cattle, sheep and goats fed either sorghum grain or molasses diets

Measurement	Grain			Molasses			SEM
	Cattle	Sheep	Goats	Cattle	Sheep	Goats	
DM intake	47 ^a	46 ^a	45 ^a	40 ^b	39 ^b	38 ^b	1.3
DM digestibility	71.2 ^a	70.1 ^a	70.8 ^a	55.9 ^b	52.0 ^b	56.5 ^b	2.02
Liveweight gain	6.5 ^a	6.3 ^a	6.3 ^a	3.3 ^b	3.1 ^b	3.1 ^b	0.61
N digestibility	92.0	84.2	84.1	89.9	86.2	85.3	10.3
N balance	901 ^a	466 ^b	332 ^b	288 ^b	116 ^{bd}	92 ^d	131
ADN retained	70.9 ^a	44.7 ^b	37.0 ^b	33.2 ^b	12.5 ^{bd}	10.8 ^d	9.8
Rumen ammonia	271 ^a	172 ^b	264 ^a	129 ^c	70 ^d	105 ^e	34.1
Rumen VFA	192 ^a	32 ^b	36 ^b	143 ^c	55 ^d	56 ^d	26.9
VFA molar proportions (%)							
Acetic acid	55.1 ^a	66.6 ^b	64.8 ^b	43.2 ^c	62.1 ^b	62.2 ^b	6.7
Propionic acid	23.2 ^a	22.9 ^a	25.1 ^a	15.1 ^b	30.3 ^a	30.1 ^a	5.3
Butyric acid	21.7 ^a	8.6 ^b	9.1 ^b	41.7 ^c	6.4 ^b	6.0 ^b	2.4

Values within a row with different superscripts differ significantly (P < 0.05).

showed significantly (P < 0.05) higher proportions of butyric acid and lower proportions of propionic acid in rumen fluid than did sheep and goats given the same diet. Sheep and goats fed either grain or molasses showed higher proportions of acetic acid in rumen fluid than did cattle.

DISCUSSION

Effects of diet on DM intake, liveweight gain and nitrogen digestion in cattle, sheep and goats

Comparisons between cattle, sheep and goats have been made after appropriate scaling for differences in body size (kg^{0.9}) (Graham 1972). Cattle voluntarily consumed less dry matter as molasses than as grain and the lower liveweight gains of animals fed molasses are likely due to the low voluntary consumption of digestible dry matter. The usefulness of molasses as a substitute energy source for grain is limited by low digestible DM intake and low propionate levels in the rumen fluid of cattle (Table 2). In the present experiment sheep and goats fed sorghum grain had similar DM intakes. El Hag *et al.* (1984) have shown that sheep fed sorghum grain had higher DM intakes than goats. Wethers and ewes given grain had similar DM intakes and liveweight gains which agrees with the results of Ahmad and Lloyd Davies (1986). The higher growth rate of bucks given the grain diet compared with does is similar to the findings reported by Ash and Norton (1987). The superior growth rate of animals given sorghum grain when compared with those given molasses was associated with an improved N retention. It is possible that sorghum provided glucose from by-pass starch which then enhanced N retention. Irrespective of diet, cattle utilized absorbed N with a higher efficiency than did sheep and goats, and had higher N contents in their liveweight gain.

Effect of grain and molasses on VFA and ammonia concentrations in rumen fluid

On both diets, cattle had higher proportions of butyric acid in rumen fluid than did sheep and goats. Cattle consuming molasses had significantly lower proportions of propionic acid in rumen fluid than did sheep and goats. Sheep and goats had similar fermentation patterns on molasses and grain. Marty *et al.* (1973) have reported that the ruminal fermentation pattern in sheep was not altered when increasing amounts of molasses were infused intra-ruminally. These observations suggest that whilst the fermentation patterns in sheep and goats may be comparable under grain and molasses feeding systems, neither species are a meaningful model for cattle on the same diets. Similar observations have been made for cattle and sheep fed forages, in this case, cattle proving to be more efficient utilizers of these feeds (Playne 1970). On both diets, cattle and goats had higher rumen ammonia concentrations than did sheep.

Watson and Norton (1982) have also reported that goats have higher rumen ammonia concentrations than sheep when both species were fed the same low quality roughage diet. These differences may arise from either different microbial populations in the rumen of the different species or from species differences in physiology.

The present study clearly demonstrates that small ruminants (sheep and goats) are not a relevant model for the study of cattle. The poor performance of cattle, sheep and goats given molasses compared with grain was not peculiar to 1 species, and whilst primarily associated with low intakes of molasses, the lower efficiencies of N use may suggest that during fermentation and digestion, molasses fails to supply some nutrients essential for the optimum growth of ruminants.

REFERENCES

- AHMAD, N.A. and LLOYD DAVIES, H. (1986). *Proc.Aust. Soc. Anim. Prod.* **16**: 119-22.
- AOAC (1980) In "Official Methods of Analysis", 13th ed. (Ed W. Horowitz) (Association of Official Agricultural Chemists: Washington).
- ASH, A.J. and NORTON, B.W. (1987). *Aust. J. Agric. Res.* 38: 957-69.
- DEVENDRA, C. (1975). *Turrialba* 25: 226-31.
- DOYLE, P.T. and EGAN, J.K. (1980). *Proc.Aust. Soc. Anim. Prod.* **13**: 521.
- EL HAG, M.G., EL HAG, G.A. and GAALI, E. (1984). *Inter. Goat Sheep Res.* 2: 274-82.
- GRAHAM, N.Mc. (1972). *Proc.Aust. Soc. Anim. Prod.* 9: 352-5.
- HOGAN, J.P. and WESTON, R.H. (1967). *Aust. J. Agric. Res.* **18**: 803-19.
- MARTY, R.J., DEMEYER, D.I., VAN NEVEL, C.J. and HENDERICKS, H.K. (1973). *Cuban J. Agric. Sci.* 7: 313-21.
- PLAYNE, M.J. (1970). *Proc.Aust. Soc. Anim. Prod.* 8: 511-6.
- STEEL, R.G.D. and TORRIE, J.H. (1960). "Principles and Procedures of Statistics"(McGraw-Hill Book Co. Inc.: New York)
- WATSON, C. and NORTON, B.W. (1982). *Proc.Aust. Soc. Anim. Prod.* **14**: 467-70.
- WILSON, A.D. (1977). *Aust. J. Agric. Res.* 28: 501-7.