Proc. Aust. Soc. Anim. Prod. (1974) **10**; 86

THE TREATMENT OF A TROPICAL ROUGHAGE WITH ALKALI, NITROGEN AND SULPHYR IN RELATION TO THE NUTRITIONAL LIMITATIONS OF PASTURES IN NORTHERN AUSTRALIA

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Summary

Poor quality spear grass was fed to cattle without prior treatment, or after treatment with potassium hydroxide and addition of urea and sodium sulphate. Treatment caused significant increases in the digestibility of organic matter and cell wall constituents, and in organic matter intake; as a result, calculated metabolizable energy intake rose by 51% to well above maintenance. The results are discussed in terms of the nutritional deficiencies of cattle during seasonally-dry periods of the year.

I. INTRODUCTION

The short growing season of many pasture plants in northern Australia forces cattle to graze mature forage for much of the year. During such times grasses in particular consist mainly of cell wall with a small proportion of cell contents. The low nutritional quality of the resulting forage, characterized by high fibre, low protein and low digestibility, is well known (Milford 1960). More recently the specific inadequacies of some species (e.g. Playne and Haydock 1972) and their poor utilization by both cattle and sheep (Siebert and Kennedy 1972) have been demonstrated.

Selection of new pasture species which demonstrate adaptation to the area during the dry season is in progress (Burt et al. 1970). Currently, however, non-protein nitrogen supplements are being used to minimise weight loss of the grazing stock during the seasonally-dry period of the year (e.g. Winks, Alexander and Lynch 1970). In specific circumstances additions of nitrogen and sulphur to poor quality spear grass have increased feed intake to above maintenance requirements (Siebert and Kennedy 1972). Results with supplements are generally inconsistent. One probable reason is the wide variations in pasture composition both within and between years.

Because of the high fibre content of dry season roughage, sufficient energy may not be available for optimum microbial activity in the rumen. The experiment reported here analyses the effect firstly that potassium hydroxide treatment has on subsequent digestion and secondly that this treatment, with addition of nitrogen and sulphur, has on metabolizable energy intake. Alkali digestion of roughages has been carried out for many years, but more recently spraying techniques that avoid washing have been attempted (Ololade, Mowat and Winch 1970; Hogan and Weston 1971; Fernandez Carmona and Greenhalgh 1972). The subject of alkali treatment and steam processing of lignocellulose material for ruminant use has been discussed by Pigden and Bender (1972). The results of treatment are discussed in terms of the nutritional limitations of cattle grazing poor quality pasture and the possible role of such treatments in fodder conservation procedures.

II. MATERIALS AND METHODS

(a) Animals

Four Brahman x Shorthorn (Droughtmaster) steers of about 18 months of age were used in the experiment.

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(b) Feeds

(i) Untreated

Mature spear grass (Heteropogon contortus) was harvested from an unfertilized area of the Lansdown Pasture Research Station near Townsville, during October 1972, and coarsely milled through a 5 cm screen. Composition of this material is given in Table 1.

TABLE 1

Composition of untreated spear grass and that treated with potassium hydroxide, urea and sodium sulphate

Constituent	Untreated spear grass	Treated spear grass
Organic matter (g/100 g DM)	92.9	89.7
Nitrogen (g/100 g DM)	0.34	0.54
Potassium (g/100 g DM)		
Cell wall (g/100 g OM)	82.8	82.2

(ii) Treated

Milled hay in 50 kg lots was sprayed during mixing in a rotating feed mixer with 15 1 of a solution of commercial grade potassium hydroxide (10% w/v). The treated hay was left overnight then neutralized with 10 1 of hydrochloric acid (15% w/v) then sprayed with a solution of urea (0.5 g nitrogen (N) per 100 g feed) and sodium sulphate (0.05 g sulphur (S) per 100 g feed). The composition of the treated feed is also given in Table 1.

(c) Animal management and digestion measurements

The procedures followed were as reported by Siebert and Kennedy (1972).

(d) Palatability test

Separate to the main experiment, the four steers were offered the free choice of the untreated and treated feeds together with hay from the same cut treated in the same manner with sodium hydroxide (10% w/v). Preference was measured over 4 days.

(e) Chemical analyses

The analyses for dry matter (DM), organic matter (OM) and N were as reported by Siebert and Kennedy (1972). Samples of feed, feed residue and faeces were analysed for cell wall constituents (CWC) by the method of Van Soest and Wine (1967).

(f) Experiment design and statistical analysis

In the digestion experiment treatment effects from the 2 x 2 crossover design were determined by analysis of variance techniques. In the palatability test all 4 steers were offered the various feeds at the same time and daily intake calculated.

III. RESULTS

(a) Palatability

After 4 days of free choice of 3 feeds the daily intake of each was as follows: Untreated feed, Nil; sodium hydroxide treated feed, 0.7 kg/head/day; potassium hydroxide treated feed, 3.5 kg/head/day.

(b) Intake, digestion and excretion of nutrients

Alkali treatment plus addition of nitrogen and sulphur significantly increased the digestibility of OM and CWC and the intake of OM (Table 2). As a result, calculated metabolizable energy intake (ME) increased by 51%. Nitrogen intake under both conditions was inadequate for requirements and treated feed only contained 0.54 g/100 g DM. The percentage increase in faecal N excretion was similar to that of ME intake when the animals were fed the treated roughage, but the animals receiving the untreated feed excreted more N in the urine. Potassium added during treatment was sufficient to bring the animals into positive K balance. Although there was no significant difference in the CWC of the feeds (Table 1), there was in the faeces of animals fed the different feeds because of increased digestibility of the CWC.

TABLE 2

Mean values (± S.E.M.) of intake, digestion and excretion of energy, nitrogen and potassium of Droughtmaster steers (mean) body weight 212 kg)

Measurement	Untreated spear grass	Treated spear grass	Significance of difference
Organic matter intake (g/day)	2388 ± 188	3607 ± 150	*
Organic matter digestibility (%)	52.8 ± 0.76	57.8 ± 1.10	**
Metabolizable energy intake‡ (k J/kg $BW^{0.75}$/day)	363.5 ± 21.5	548.8 ± 13.8	**
Digestibility of CWC (%)	56.1	63.8	*
Nitrogen intake (g/day)	8.5 ± 0.5	21.4 ± 1.1	**
Urinary nitrogen (g/day)	10.7 ± 1.8	6.6 ± 1.3	*
Faecal nitrogen (g/day)	14.5 ± 0.4	20.67 ± 1.73	**
Potassium intake (g/day)	9.8	86.6	

* $P < 0.05$ ** $P < 0.01$

‡ Digestible energy intake (k J/kg $BW^{0.75}$/day) x 0.83

IV. DISCUSSION

Those areas of northern Australia subject to seasonally-dry conditions frequently contain native pastures that mature rapidly with a resultant low proportion of cell content (Milford 1960). When this is so, metabolic activity of rumen microflora may be limited by the supply of soluble carbohydrate, nitrogen, sulphur and possibly some electrolytes. The level of intake of such pastures by ruminants is primarily controlled by the rate of fibre digestion (Weston 1967) and hence any disturbance in microbial activity in the rumen soon results in a decline in feed intake. Even when mineral deficiencies are overcome, however, the fibre may be so resistant to digestion that voluntary feed consumption may not be adequate to maintain the animal.

The low nitrogen content and low digestibility of mature roughages in the tropics has been documented frequently (e.g. Shaw and Bisset 1955; Milford 1960). More recently the role of sulphur has been investigated (Playne 1969a; Siebert and Kennedy 1972; Kennedy and Siebert 1972); additions of nitrogen and sulphur have been found to increase significantly the intake of spear grass by cattle. A question raised by the present experiment was the possible influence of the level of potassium. Examination of the data of Ritson, Edye and Robinson (1971), Playne and Haydock (1972) and subsequent analyses of previously collected samples of tropical grasses reveal that after mid-year potassium is frequently only present in concentrations of < 0.5 g K/100 g DM. As it is an element quickly excreted by the herbivore, a deficiency state can arise at this level. Devlin, Roberts and St. Omer (1969) have clearly shown increasesin feed intake and body weight by cattle by supplementations with potassium up to levels of 0.71 g K/100 g DM. Further experiments are being carried out at present to clarify this point with spear grass dominant pastures.

Other elements such as phosphorus, calcium and sodium are often present in low concentrations (Playne and Haydock 1972), but their turnover rate is frequently slower than nitrogen, sulphur or potassium and more time is required to establish a deficiency state in the animal (McDonald 1968). Supplements of some elements (e.g. P) are sometimes ineffectivein raising feed intake since either nitrogen deficiency or resistance of fibre to breakdown primarily limits rate of passage and hence intake by the animal. This was demonstrated in a comparison of Townsville stylo and spear grass of similar phosphorus content (Playne 1969b). When both were fed to sheep with a supplement of calcium phosphate, animals increased their intake of the legume but failed to do so with spear grass. Low phosphorus pasture is found extensively and responses to supplementation have been noted from Charters Towers (Mutch 1970) to Cape York (Winter, unpublished information), On many occasions, the situation is confounded with low protein content. Trace element deficiencies probably occur from time to time, but usually the gross deficiencies over-ride these. Copper deficiency has been recognized in north Queensland breeding stock (Donaldson et al. 1964) and copper and cobalt deficiencies are currently being investigated in a high rainfall area (Winter and Siebert unpublished information).

Direct supplementation of deficient nutrients and minerals is one means of overcoming the limitation placed on cattle production. If supplements include soluble carbohydrate in the form of molasses, grain or high quality hay, the energy derived from these sources may substitute part of that normally derived from the basal forage. This substitution effect causes intake of the poor quality material to decline. If soluble carbohydrate is not included, energy intake will still be based on the physical characteristics of the original roughage. In some circumstances, cattle appear able to consume their maintenance needs with nitrogen plus molasses or sulphur supplements (Winks, Alexander and Lynch 1970, Siebert and Kennedy 1972). Such a result is not consistent however (e.g. Alexander, Daly and Burns 1970) and intakes of roughage cut at varying times of the year and in different years are not adequate on every occasion to meet the reported maintenance needs of cattle (Siebert and Kennedy unpublished information). The experiment reported here was aimed at supplying more energy to the microflora by chemical treatment. Since there was no actual supplement of energy involved, no substitution of roughage could occur.

The technique used in the present experiment was novel in two ways. Potassium hydroxide (the common cation of plant material) was used instead of sodium hydroxide, and low-cost hydrochloric acid was used for neutralization instead of dearer organic acids such as propionic. The latter is often used to avoid mould growth but in a dry tropical climate atmosphere during mid-year, moistened roughage dries quickly in the open. The resulting product was eaten more readily than that treated with NaOH. Digestibility of organic matter rose by about 5% and metabolizable energy intake rose by 51% to well above the reported maintenance requirements of similar type of cattle fed tropical roughages (417 MJ/kg $BW^{0.75}$/day, Vercoe 1971).

The possibility of using the process in connection with a fodder conservation procedure is attractive. The cost of the reagent chemicals for the process was near $30.00 per tonne of dry feed which would supply 31 MJ of metabolizable energy per day to animals of 200 kg body weight for 250 days. The same amount of energy could be supplied by about 0.75 tonne of high quality hay or 0.61 tonne of grain.

A number of nutritional deficiencies or limitations are placed on cattle production because of the quality of pasture during the dry season of northern Australia. Supplementation of missing nutrients, plant introduction or treatment of the present roughages are possible ways of overcoming these limitations.

V. ACKNOWLEDGEMENTS

I wish to thank Mr. M.J. Breen and Mrs. C. Noble for technical assistance.

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