A COMPARISON OF COTTONSEED AND FORMALDEHYDE-TREATED SUNFLOWER MEALS ON THE PRODUCTION OF *BOS INDICUS* AND *BOS TAURUS* CATTLE ON A SUB-TROPICAL PASTURE HAY

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Summary

Six steers of each breed type, Hereford (HxH), Brahman (BxB) and Brahman x Hereford (BxH) were ranked on liveweight and allocated to three treatments, basal hay diet (Basal), Basal plus 1 kg/head/day of cottonseed meal (Basal + CSM) and Basal plus 1 kg/head/day of formaldehyde-treated sunflower meal, Norpro® (Basal + NPO). The hay was made from a pasture based predominantly on carpet grass (*Axonopus affinus*) growing in subtropical New South Wales, and had an estimated organic matter digestibility of 52% and a nitrogen (N) content of 7.8 g/kg dry matter (DM). The steers were accustomed to the Basal diet over 15 days and supplements offered over 42 days. Intake of the basal hay diet by steers was not increased by supplementation. When intakes were adjusted for differences between breed types in liveweight the BxH steers ate 25% ($P < 0.01$) more hay than HxH steers (6.3 V 5.0 kg/head/d) and BxB steers ate 8% less hay than HxH steers. Supplementation significantly ($P < 0.01$) increased liveweight gain during the experiment, being (g/head/d ± s.e.d.) 290, 770 and 795 ± 118 respectively for Basal, Basal + NPO and Basal + CSM. There was no difference between supplements in the liveweight gain of steers nor between steers of different genotypes. However, there was a significant interaction ($P < 0.01$) between breeds and treatments such that BxB steers gained most on the basal diet but least of the breed types when supplemented. The estimated non-degradable fraction of N in the protein meals was 58.5 and 44.5%, respectively for NPO and CSM. Both meals increased ($P < 0.01$) plasma urea N and rumen ammonia N concentrations.

(Key Words: Brahman, Hereford, Protected Protein, Cottonseed Meal, Sunflower Meals, Pasture Hay, Rumen Ammonia)

Introduction

Beef cattle generally decrease in liveweight during winter when grazing unimproved native pastures in the subtropics (Cohen and O'Brien, 1974; Hennessy et al., 1981). This decline, can be arrested by the use of protein meals as a supplement during the winter period (Hennessy et al., 1981) but not by supplementation with cereal grains, such as sorghum. Alternatively, it has been proposed that urea can be used as a nitrogen supplement, often with molasses, for cattle grazing dry pastures to reduce their weight losses (Burns, 1965; Winks et al., 1979). However, supplementation with protein meals has given more consistent responses in liveweight gain than does urea supplementation (Hunter and Siebert, 1980), and particularly if some of the proteins are resistant to rumen degradation (Leng et al., 1977). Cottonseed meal is one such meal with a high proportion of non rumen degradable proteins (Hennessy et al., 1983) but, in general, vegetable oilmeals are moderately degradable. The degradability in the rumen of proteins in vegetable meals is reduced by the judicious spraying of the meals with chemical aldehydes (Ferguson et al., 1967). The value of these meals to livestock production is therefore increased substantially (Ferguson, 1975; Coombe et al., 1987).

This paper reports the effect of a formaldehyde-sprayed sunflower meal (Norpro®; Norco Co-op

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Pty. Ltd., Lismore, N.S.W.) on the feed intake, and the growth of steers offered a low protein pasture hay and on the concentrations of urea N in plasma and ammonia N in rumen fluid. These responses are compared with those obtained with cottonseed meal. Because of the increasing number of *Bos indicus* cattle in the sub tropics, the experiment includes two of these types to compare with Hereford (*Bos taurus*) cattle, at present the popular breed, since purebreed *Bos indicus* cattle might have lower protein requirements, or respond less to supplements than might Hereford steers (Hunter and Siebert, 1985a).

Materials and Methods

Animals

Eighteen steers, 10 months of age, were selected for the experiment and cleared of internal parasites by drenching with an anthelmintic (10% w/v fenbendazole; Hoechst Ag. (Aust.) Pty. Ltd.). Six steers were Hereford (*Bos taurus*) (HxH), six were Brahman (*Bos indicus*) (BxB) and six were the F_1 generation, Brahman x Hereford (BxH) with mean initial liveweights (± s.e.) respectively of 232 ± 5; 278 ± 7 and 246 ± 6 kg. All the steers were purchased from commercial properties in central Queensland. After an initial accommodating period, and drenching, the steers were ranked into three strata per breed and allocated, two per breed, to three treatments. They were placed in pens under cover and fed the basal experimental diet for 15 days prior to supplementation.

Pasture hay

The basal diet consisted of a hay made from a native pasture and cut at the end of its summer growth (March). The pasture consisted predominantly of carpet grass (*Axonopus affinus*) but contained some native grasses (e.g. *Dicanthium*, *Andropogon* and *Digitaria*), patches of blady grass (*Imperata cylindica*) as well as sedges (*Cyperus* spp.) and tufted rushes (*Kyllinga* spp.). It also contained some (< 4%) Bargoo joint vetch (*Aeschynomene falcata*), a summer growing legume. The hay was cut through a forage chopper into 30 ± 10 mm lengths and upon analysis contained 7.8 g N/kg DM, 91% dry matter (DM) and a digestibility (organic matter), estimated from an *in vitro* technique (Alexander and McGowan, 1961), of 52%.

Housing and feeding

After a 15-day adjustment to the basal hay diet, steers were fed hay *ad libitum* for 42 days, divided into six, 7-day periods. The three treatments consisted of supplementation with nil (Basal), cottonseed meal (BCSM) or formaldehyde-treated sunflower meal (BNPO) during the 42 days; supplements being offered in containers separate from the hay. NPO was produced by spraying sunflower meal with a solution containing formaldehyde at the rate of 6 g formaldehyde/kg crude protein (D.L. Lambourne, *pers. comm.*).

Hay was offered to cattle at 09.00 h, 11.30 h and 16.00 h in amounts aimed at being 1.15 of daily intake. Hay remaining each morning was bulked for each steer over a 7-day period. Protein meal supplements were given at a daily rate of 1 kg (air dry)/head and offered in two meals at 08.30 and 16.00 h. Air dry CSM was 89% DM and contained 67.8 g N/kg DM, with NPO being 88% DM and containing 55.8 g N/kg DM. Steers consumed all the protein meal offered, and generally within 20 minutes.

Hay intake was recorded on a DM basis as the difference between the amount offered over 7 days less the daily residue collected over a 7-day period; there being one day lag between these periods.

Recordings and samples taken

Liveweight was recorded before the morning offering of hay on the day supplementation commenced, and then every 7 days. Samples of rumen contents were obtained *per se* on day 30 by locating a rubber tube into the rumen and aspirating the contents into a McCartney bottle. Any sample with pH > 7.2 was discarded on the likelihood that it was contaiminated by saliva. Rumen samples were acidified with 0.2 mL of 18 mol H_2SO_4 to lower the pH < 3.0, centrifuged at 2000 g and the supernatent liquid decanted and stored at −18°C. Blood was taken from the coccygeal vein directly into heparinised tubes when rumen samples were taken. The blood tubes were centrifuged, plasma decanted and stored at −18°C.

The rate of nitrogen disappearance from CSM, untreated sunflower meal (SFM), and NPO, was determined by placing ground samples in terylene bags (pore size 20 μm) and suspending in the rumen of a fistulated steer over time. For each meal, sixteen bags containing 5 g samples were

placed into the rumen of the steer grazing a matured subtropical grass (*Pennisetum clandestinum*). The nitrogen content was calculated for each sample removed at 3 h intervals for 12 h; 6 h intervals to 24 h, and 12 h intervals to 48 h. The proportion of N remaining was estimated as described by Hennessy et al. (1983), assuming a mean particle retention time for the meals in the rumen of 15 h. Degradability of the total N fraction of the three protein meals was calculated from equation 2 of Orskov and McDonald (1979).

Laboratory analysis

The DM content of hay and meal samples was determined by drying in a forced-draught over for 24 h at 73°C. Nitrogen content of the samples was determined in a colorimeter (Havilah et al., 1977) after a micro-Kjeldahl digestion (Se catalyst) of material that had been ground to pass through a 0.5 mm sieve. Ammonia in rumen fluid samples was also estimated by the colorimetric technique of Havilah et al. (1977). Urea concentration in plasma was determined colorimetrically by the diacetyl monoxime reaction (Marsh et al., 1965). Volatile fatty acid (VFA) concentrations and proportions were measured using a gas chromatograph (Unicam, model 604). The column (1.8 m x 3 mm, internal diameter) was packed with 17.5% w/w polypropylene glycosepacate and 1.5% w/w orthophosphate chromasorb W-AW (60-80 mesh). The internal standard was 4-methyl valeric acid.

Statistical analysis

All data were analysed according to the generalised linear model of Nelder and Wedderburn (1972). Hay intakes of individual steers for each of the six subperiods were analysed by a multivariate repeated measures analysis in the programme GENSTAT (Alvey et al., 1980), developed by the Rothamsted Experimental Station. Both linear and quadratic contrasts of hay intake were examined against time, with the intake during the preliminary period included as a covariate. Liveweight change over 42 days was analysed by a

TABLE 1. FINAL LIVEWEIGHT (ADJUSTED FOR DIFFERENCES BETWEEN BREEDS IN INITIAL LIVEWEIGHT), LIVEWEIGHT CHANGE, HAY INTAKE AND FEED CONVERSION RATIO OF STEERS DURING THE EXPERIMENT (42 DAYS) ACCORDING TO BREED TYPE AND TREATMENT, WITH RUMEN AMMONIA AND PLASMA UREA CONCENTRATIONS ON DAY 30 OF THE EXPERIMENT

Items	Treatment groups									s.e.d.[1]
	Basal			BCSM			BNPO			
	HxH	BxH	BxB	HxH	BxH	BxB	HxH	BxH	BxB	
Liveweight (kg)	238	250	294	270	289	307	263	285	310	6.6[3,4]
Liveweight change (g/d)[8]	270[a]	200[a]	390[ab]	760[bc]	880[c]	750[ab]	775[bc]	940[c]	595[ab]	157[2]
Hay intake (kg DM/d)	5.0	5.9	5.0	5.5	6.6	5.2	5.4	6.5	5.2	0.4
(g DM/kg LW)[8]	21.1[bc]	23.7[c]	18.5[b]	20.6[b]	23.0[bc]	16.9[a]	20.5[b]	22.9[bc]	16.8[a]	1.2[2,3]
Feed conversion ration (kg/kg)[5]	18.5	29.9	13.7	8.4	8.5	8.0	8.1	7.8	10.1	0.8[4]
Rumen volatile fatty acids (m mol/L)[6]	76	63	71	99	57	58	67	61	64	17.4
Rumen ammonia (mg N/L)	35	35	39	59	64	52	63	54	61	8.8[5]
Plasma urea (mg N/L)	64	79	53	158	171	168	159	138	164	15.2[4]

[1]s.e.d. is standard error of difference between means.
[2]Breed x treatment interaction significant ($P < 0.01$).
[3]Breed types differ significantly ($P < 0.01$).
[4,5] Treatment effects significant ($P < 0.01$; $P < 0.05$).
[6]Feed conversion rates (kg feed intake/kg gain).
[7] Adjusted for differences between breed x treatment groups in final liveweight.
[8] Means within rows followed by unlike superscripts differ significantly.

least squares analysis of variance with initial liveweight included as a covariate. Single factor data (rumen ammonia and plasma urea concentrations) were also analysed by a least squares analysis of variance using orthogonal contrasts. Differences between treatments, based on significant contrasts are indicated as significant by different superscript letters in table 1.

Results

Liveweight

Both CSM and NPO substantially increased ($P < 0.01$) liveweight gains of steers above those offered only the basal diet of hay; these gains (g/head/d) being 795, 770 and 290 ± 118, respectively. Overall, there was no significant difference between breed types but there was a significant ($P < 0.05$) treatment x breed interaction (table 1). BxB steers were ranked with the highest gain amongst steers on the basal diet and the lowest gains for supplemented steers. The effects of the supplements on liveweight were apparent after 14 days when supplemented steers were heavier ($P < 0.05$) than steers on the basal diet (figure 1). This difference increased with time up to 42 days.

Hay intake

The mean hay intake of steers over the 42-day experiment did not differ significantly between treatment groups (table 1). However, differences between treatment groups were significant ($P < 0.05$) in periods 5 and 6 (figure 1). Hay intakes differed ($P < 0.01$) between breeds and when adjusted to the average liveweight (267 kg) BxH steers ate 25% more than HxH steers and BxB

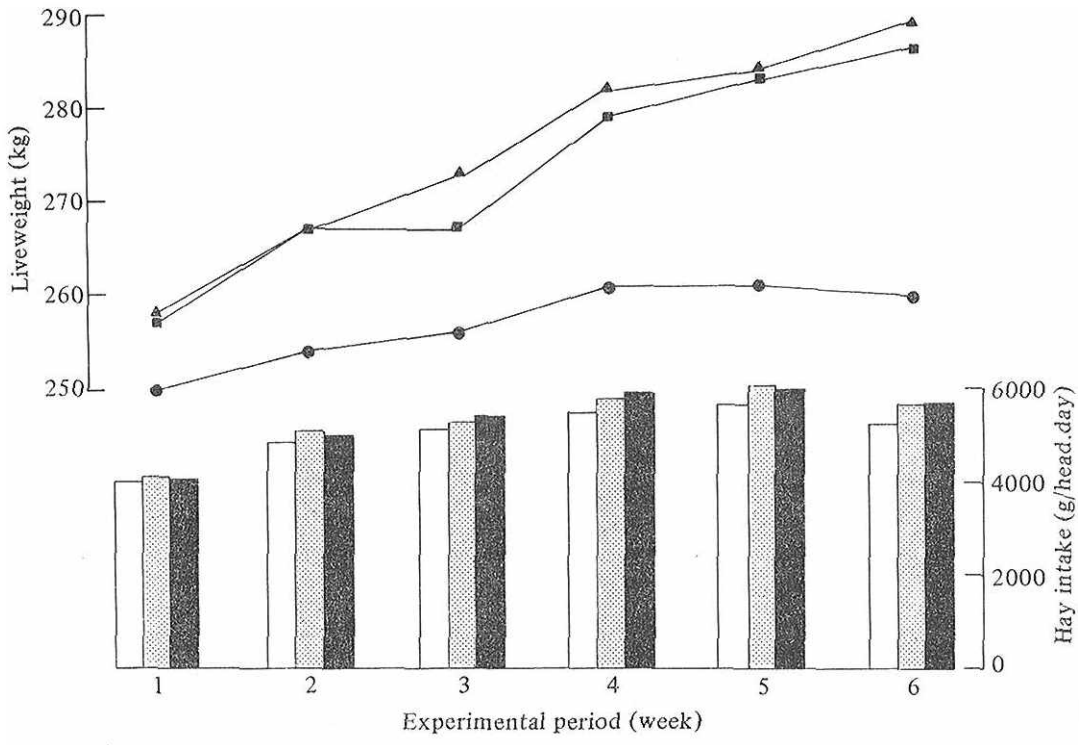

Figure 1. Liveweights of steers on a native pasture hay (●) over 42 days and of steers supplemented with cottonseed meal (▲) and formaldehyde-treated sunflower meal (NPO) (■). Mean hay intake for steers each 7 days is shown as
basal diet
formaldehyde-treated sunflower meal
cottonseed meal

steers ate 8% less. At this average liveweight, supplemented steers had higher ($P < 0.05$) hay intakes (5.5 kg/day) than non-supplemented steers (5.2 ± s.e.d. 0.15 kg/day).

BxB steers had lower ($P < 0.05$) intakes of hay per unit liveweight than other breed types (table 1). However, the feed conversion ratios (kg DM feed eaten: kg liveweight gain) were significantly ($P < 0.01$) lower for supplemented steers than these on the basal hay diet; these ratios did not differ between breed types.

Rumen ammonia and plasma urea concentrations; volatile fatty acid concentrations; degradability of N from protein meals in the rumen

Concentrations of ammonia in rumen fluid were low in steers on the basal diets (36 mg N/L) but were significantly ($P < 0.05$) increased by protein meal supplements (59 mg N/L; table 1). Plasma urea concentrations were also increased ($P < 0.01$; table 1) by supplementation, with these concentrations related to rumen ammonia concentrations ($r = 0.77$).

There was a significant ($P < 0.05$) difference between breed types in the molar concentration of volatile fatty acids (VFA). The molar concentration for HxH steers of 82 m mol/L was higher than the concentration in BxH and BxB steers (60 and 62 ± 8.7 m mol/L, respectively). These differences were not significant when adjusted for differences between steers in final liveweight (table 1).

SFM had a larger ($P < 0.05$) soluble (and including rapidly degradable) N fraction than NPO whereas the rate of N loss from the insoluble fraction was not different between protein meals (table 2).

TABLE 2. NITROGEN COMPONENTS OF THREE PROTEIN MEALS WHEN PLACED IN THE RUMEN OF A STEER

	Soluble N fraction	Rate of N loss	[1]Estimated non-degradable fraction
	% of total N	% of total N/h	% of total N
Sunflower meal	53.6	7.3	22.4
Norpro®	0.5	4.8	58.5
Cottonseed meal	11.7	6.7	44.5
s.e.d. ±	21.2	1.8	

[1]A fractional clearance rate (k) of 0.068 has been used for each meal.

Discussion

Steers on the basal, low N (7.8 g/kg DM) diet, had small (290 g/day) weight gains during the experiment. These gains, however, were unexpected in view of the substantial weight losses reported previously from other studies at this Station when penned steers were offered low N hay diets (Hennessy et al., 1983; Lee et al., 1987). The hays used in those studies had lower N contents (6.2 and 4.3 g N/kg DM) than the hay used in the present experiment, which contained a legume, Bargoo jointvetch, in the pasture. Consequently, the difference between these studies in liveweight changes could be attributed primarily to the different quality of the hays used, especially to the different N contents although other aspects, notably differences between cattle breed types and origins, would have had an effect.

Both protein meals were effective in increasing liveweight gains of steers with a small increase in their hay intake. The efficiency with which the protein meals were used can be estimated by the ratio of the extra gain of the supplemented, over the non-supplemented steers, to the additional feed intake of the supplemented steers. This estimate is 2.9 kg gain/kg feed intake, or 2.7 kg gain/kg feed intake when the BxB steers are excluded from the ratio.

The increased hay intake by supplemented steers in the order of 6% was significant only when the effects of different liveweights were included in the analysis. This is less than the 29% reported by Hennessy et al. (1983), when HxH steers were supplemented with a protein meal, or the 19% (non-significant) higher intake by *Bos indicus* crossbred steers when supplemented with formaldehyde-treated CSM (Mullins et al., 1984). There may be differences in the intake response of *Bos indicus* and *Bos taurus* steers to nitrogen supplementation, related to a putative ability to maintain higher rumen ammonia concentrations. Hunter and Siebert (1980) reported that Brahman steers' hay intake was not increased by a urea plus sulphur supplement whereas the intake of Hereford steers was increased by 20% on a low N hay (6.2 g N/kg DM). In the present study BxB

steers had substantially lower (22%) intakes than HxH steers over the whole of the experimental period, whereas BxH steers ate 15% more hay than HxH steers. At a mean common liveweight the adjusted intakes were 8% less, and 25% more, respectively. BxB steers also differed from the BxH and HxH steers in that protein meal supplements reduced their hay intake when intake was expressed as g DM/kg liveweight.

A common feature of cattle on the basal hay diet was a low concentration of ammonia in rumen fluid. Ammonia is the major source of nitrogen for a range of rumen bacterial species (Schaefer et al., 1980) and the minimum concentration range in which microbial cell synthesis is maximised has been established as 50-80 mg ammonia N/l. (Satter and Slyter, 1974). Protein meal supplements increased this concentration to within the required range. However, higher ammonia concentrations may be required to maximise forage digestion and thereby allow higher hay intakes (Mehrez and Orskov, 1978; Krebs and Leng 1984; Boniface et al., 1986). Therefore, additional benefits might have been obtained by including supplementary forms of nitrogen in the diet that would maintain even higher rumen ammonia concentrations. In practice this is difficult to achieve especially when infrequent ingestion of degradable or soluble forms of N are used in supplements for grazing stock. It is also pertinent to state that the rumen ammonia concentrations reported are likely to be the 24 h nadir, given the sampling and feeding regime used in this study. Hunter and Siebert (1985a) reported higher rumen ammonia concentrations in Brahman steers than in Hereford steers (29 vs. 14 mg ammonia N/L) when both were on a low N spear grass hay (5.8 g N/kg DM), but no such differences was recorded in the present experiment. Nonetheless in spite of the similarity of rumen ammonia concentrations there was a trend for BxB steers to have higher gains than BxH or HxH steers on the low N basal diet and this aspect requires further study to elucidate whether in general that Brahman steers have higher gains and by what physiological means they achieve them.

The nylon bag estimates on rumen degradation indicated that the spray-treatment of SFM increased substantially the proportion of non-degraded nitrogen in the meal. Untreated-SFM is not highly regarded as a protein meal supplement for ruminants, although liveweight increases in the order of 240% were reported by Coombe et al. (1987). However, these authors reported further increases of 130% when formaldehyde-treated, rather than untreated, SFM was fed to sheep. SFM is higher in the sulphur amino acid, methionine, than CSM (Anon , 1983) and much of the response of ruminants to the "protection" of SFM would be due to an increased availability and utilisation of this, and other, essential amino acids. This assumption is based on the report of Lindsay et al. (1988) of liveweight responses in cattle to formaldehyde-treated methionione when on native grass hay and which were supplemented with cottonseed meal. There is a high metabolic requirement for amino acids in net tissue synthesis for steers growing at rates in excess of 750 g/day (National Research Council, 1985), and presumably both the meals used as supplements in this study provided for this requirement. Consequently, most of the increased efficiency of liveweight change in the supplemented cattle is attributed to a greater flow of protein to the intestines (from microbial and dietary origins). This increased flow would have improved the balance of nutrients and increased the efficiency of energy utilisation (Black et al., 1987). Notwithstanding the effect of the improved protein flow was the addition of approximately 12 MJ of metabolisable energy from the intake of 1 kg of either meal, thereby increasing the available energy for growth in the cattle.

The conclusions from this study are that both NPO and CSM are suitable supplements to beef cattle for improving their utilisation of low N native grass forage. Nonetheless, the rumen ammonia concentrations were somewhat lower than is desired, since low concentrations are associated with reduced rumen digestion rates and reduced feed intakes in both *Bos taurus* and *Bos indicus* cattle on low N hays (Hunter and Siebert, 1985a, b). In an attempt to increase these concentrations the usefulness of the supplements could be enhanced by adding to each supplement a low-cost degradable protein (or non protein source of nitrogen). In the case of NPO, a lower rate of formaldehyde application would increase nitrogenous concentrations in the rumen and therefore be a more appropriate product for beef cattle on low N forages. For the present, the choice of which supplement to use depends on

its availability and cost. However, in this study the Brahman steers were the least responsive to supplementation and whilst graziers should accept smaller net returns from supplementation of Brahman cattle in tick-free (*Boophilus microplus*; Canestrini) areas, the reasons for the lower response to protein supplementation by purebred Brahman steers requires further investigation so that firm guidelines on supplementation can be established for this breed.

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