# WHOLE COTTONSEED SUPPLEMENTS FOR CATTLE GIVEN A MOLASSES-BASED DIET

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## SUMMARY

The effects of inclusion of whole cottonseed (WCS) in a molasses-based diet for cattle were investigated in a pen study over 63 days. Nine rumen-cannulated Hereford steers (172 kg) were given *ad libitum* access to a molasses-based ration comprising molasses plus (as a percent of molasses, w/w as fed) 3% urea, 1% sodium dihydrogen phosphate and 5% water, together with wheat straw fed at 0.75% of liveweight (LW; DM basis) per day, and 200 g/day of cottonseed meal. Treatment supplements were (daily allowances, as fed): (i) CS200 - 200 g WCS + 55 g urea; (ii) CS500 - 500 g WCS + 37 g urea; and (iii) CS1000 - 1000 g WCS; the supplements were isonitrogenous. Intake of the molasses mix was not affected by treatment but total DM intake was increased when 1000 g/day of WCS was fed compared with the other two treatments (32.8 *v.* 28.4 g/kg LW.day; $P<0.05$). Over the total feeding period, steers receiving 1000 g/day WCS had higher growth rate (1.20 kg/day) than those receiving 500 (0.76 kg/day) or 200 (0.78 kg/day) g/day WCS ($P<0.05$), but the main response period was in the first 4 weeks of feeding when corresponding growth rates were 1.47, 0.75 and 0.45 kg/day respectively and differences between treatments were significant ($P<0.05$) as for the total period. The concentration of ammonia-nitrogen in rumen fluid, averaged over 24 hours, declined as intake of WCS increased, and thus as the amount of urea included in the diet to equilise nitrogen was reduced, so that the concentration for the CS1000 group (5.2 mM) was lower ($P<0.01$) than for the other two groups (9.1 mM). There was no effect of treatment on the total concentration or molar proportions of volatile fatty acids, or on the population density of protozoa. This study indicated that inclusion of WCS in molasses-based rations could substantially improve animal performance, but further research is required to identify the causative agent(s) and thereby develop cost-effective feeding strategies for cattle in northern Australia.

*Keywords*: molasses, whole cottonseed, cattle, supplements

## INTRODUCTION

In coastal northern Australia, molasses is a relatively inexpensive energy source for beef cattle, and is widely used for both drought and production feeding. Whole cottonseed (WCS) is another readily available by-product of agriculture in northern Australia which seems to provide some desirable attributes for inclusion in molasses-based rations. It is moderately high in protein content, and inclusion of a source of bypass protein in high-molasses rations has been associated with substantial increases in growth rate (see Preston and Leng 1987). It also has high energy content, by virtue of its high fat analysis, which may ameliorate the suggested low net energy value of molasses when the molasses is fed as a high proportion of the total diet (Lofgreen and Otagaki 1960). Furthermore, there has been speculation that inclusion of high fat sources in diets based on molasses, which itself contains virtually no lipid, will have a glucose-sparing effect. Glucose is required for production of glycerol and reducing equivalents for fat synthesis and is considered a potentially limiting nutrient on high molasses diets (Preston 1972).

Bird and Leng (1978) demonstrated that the growth rate of steers given a basal diet of molasses/urea was increased when protozoa were eliminated from the rumen. Various studies with ruminants fed forage-based rations have indicated that inclusion of feed sources with high lipid content will markedly reduce protozoa population density in the rumen (Ikwuegbu and Sutton 1982; Bird and Dicko 1987). It is possible, therefore, that WCS could have a similar effect on molasses-based diets, with implications for improved animal performance. This experiment was set up to investigate the effects of inclusion of increasing amounts of WCS in molasses-based rations on the growth rate and rumen function of steers.

## MATERIALS AND METHODS

*Experimental animals, design and diets*

Nine rumen-cannulated Hereford steers *ca* 12 months of age and weighing 172 (s.e. 7.4) kg initially were tethered in individual pens. Cannulation had been carried out 3 months prior to the start of the experiment.

The steers were allocated to three treatment groups each of three steers by stratified randomisation on the basis of fasted (24 hours without food and 16 hours without water) liveweight (LW). All steers were given *ad libitum* access to a molasses-based mix (hereafter molasses/urea) comprising molasses plus (as a percent of molasses, w/w as fed) 3% urea, 1% sodium dihydrogen phosphate and 5% water, together with wheat straw fed at 0.75% (dry matter; DM) of LW/day, and 200 g/day of cottonseed meal. The wheat straw was chaffed to approximately 2-5 cm lengths. Treatment supplements were (daily allowances, as fed): (i) CS200 - 200 g WCS (fluffy white) + 55 g urea; (ii) CS500 - 500 g WCS + 37 g urea; and (iii) CS1000 - 1000 g WCS, with the urea included to balance supplements for nitrogen content. A monthly injection of vitamins A, D and E was administered to prevent deficiencies.

*Procedures*

The basal diet of straw and molasses/urea but without cottonseed meal was fed for 3 weeks prior to the start of the experiment in order to accustom the steers to the diet. Wheat straw was fed once daily at 0800 hours with the supplementary urea, dissolved in a small amount of water, cottonseed meal and WCS sprinkled on top. The daily allowance of wheat straw for each steer was recalculated weekly based on the most recent LW determination. Molasses/urea was fed out in troughs separate from the other dietary components at a level sufficient to maintain *ad libitum* intake. Residues of the molasses were collected, weighed and subsampled once weekly, and DM content determined. Representative samples of all feed components were also subsampled weekly for determination of DM, and were bulked over *ca* 30 days for chemical analysis. Steers were weighed unfasted once weekly, prior to feeding in the morning. The experiment continued for 63 days.

On day 54, rumen probes were inserted through the cannulae and rumen fluid was sampled immediately before feeding the straw (0 hours) and at 2, 4, 6, 8, 10, 12, 15, 18, 21 and 24 hours after feeding. Samples were sub-sampled as follows: 4 mL was mixed with 16 mL of 10% formal saline for protozoal counting and 15 mL was transferred into McCartney bottles containing 4 drops of concentrated $H_2SO_4$ and then stored at -20°C awaiting analysis for ammonia-nitrogen ($NH_3$-N) and VFA concentrations.

*Statistical analysis*

Data were subjected to analysis of variance according to a completely randomised design. Separate analyses of the intake and liveweight data were carried out for the first 4, the last 5 and for all 9 weeks of the experiment. Differences between means were tested using the least significant difference (l.s.d.) procedure (P=0.05). Data involving repeated measures over time, eg. liveweight and VFA concentration, were subjected to repeated measures analysis of variance (BMDP; Dixon *et al.* 1983).

**RESULTS**

The wheat straw, WCS and cottonseed meal contained, respectively per kg DM, 878, 962 and 919 g organic matter (OM); 9.1, 34.7 and 72.6 g nitrogen (N); and 8.1, 197.0 and 17.2 g fat (ether extract). Molasses was 72.9% DM and contained 860 g OM and 6.2 g N/kg DM.

Feed intakes and liveweight gains are shown in Table 1. Total DM intake (expressed per unit LW) and growth rate were significantly increased by feeding the highest level of WCS when compared with other treatments. The main response period was in the first 4 weeks of feeding, when LW gains were 0.45, 0.75 and 1.47 (s.e. 0.141) kg/day for steers receiving 200, 500 and 1000 g/day of WCS, respectively, and treatment effects were the same as those for the total period ($P<0.01$). During the final 5 weeks there were no significant treatment differences, with growth rates averaging 0.93 (s.e. 0.063) kg/day overall.

The concentration of $NH_3$-N in the rumen fluid of steers was higher ($P<0.01$), on average, for treatments CS200 and CS500 (9.5 and 8.7 mM) which received urea in the supplement, than for CS1000 (5.2 mM). The treatment x time effect was also significant ($P<0.05$), with the main differences evident in the first 6 hours after feeding when group CS200 had higher $NH_3$-N concentration in rumen fluid than the other groups. Intake of WCS had no significant effect on VFA total concentration (average 89, s.e. 6.6 mM) or molar proportions (acetate 576, propionate 235, butyrate 175 mmol/mol) in the rumen fluid of steers. Protozoal numbers were highly variable between animals within groups, and there were no treatment differences (average 4.7, s.e. 1.60 x $10^4$/mL).

**Table 1. Effects of treatment (details in text) on food intake and on the liveweight (LW) gain of rumen-cannulated steers offered a basal diet of molasses/urea over 63 days**

| Treatment | Intake (kg DM/day) | | | | Total | LW gain |
|---|---|---|---|---|---|---|
| | Molasses/urea | Straw | Supplement[A] | Total | (g DM/kg LW/day) | (kg/day) |
| CS200 | 4.03 | 1.38 | 0.41 | 5.82 | 28.8[aB] | 0.78[a] |
| CS500 | 3.40 | 1.39 | 0.67 | 5.46 | 27.9[a] | 0.76[a] |
| CS1000 | 4.49 | 1.51 | 1.09 | 7.09 | 32.8[b] | 1.20[b] |
| s.e. | 0.412 | | 0.510 | 0.11 | 0.094 | 0.094 |

[A] Includes whole cottonseed, cottonseed meal and urea fed with straw.
[B] Means in the same column with different superscripts are significantly different (P<0.05).

## DISCUSSION

The excellent growth rate achieved by our experimental animals (1.2 kg/day) when 1000 g/day of WCS was included in the molasses-based ration approached that achievable on grain-based feedlot rations, albeit that the duration of feeding was short. We can see no reason why cannulation of the steers would have affected their growth performance, as ample time was allowed for recovery from surgery and for any compensatory growth to occur prior to commencement of the experiment.

The growth responses to feeding increasing amounts of WCS generally followed trends in total DM intake. Converting these DM intakes into ME intakes, by assuming ME content in molasses, straw, cottonseed meal and WCS of 10.9, 6.2, 11.3 and 13.6 MJ/kg DM (NRC 1996), provides estimates for ME intake of 57.1, 54.0 and 72.9 MJ/day for steers receiving 200, 500 and 1000 g CSM respectively, indicating a similar close association between energy intake and growth rate. Thus the higher growth rate with 1000 g/day of WCS was apparently mainly in response to the additional energy supplied by the WCS since there was no significant change to the intake of molasses/urea. The possible reasons for these intake responses and their resultant effect on growth rate are discussed below.

It is difficult to explain why the major growth responses occurred during the first half of the experiment, especially as the steers were given quite a long equilibration period before the experiment commenced. One possibility is a gut-fill effect but it is unlikely that the difference in liveweight of *ca.* 30 kg between steers receiving 200 and 1000 g/day of WCS over the first 4 weeks was due to differences in gut-fill alone. This requires further investigation in a longer term feeding study.

The lack of substitution of WCS for molasses at the highest level of WCS feeding has a parallel in the findings of Gaya *et al.* (1979) who reported increased growth rate of heifers, but no reduction in molasses/urea intake, when fish meal was provided as a supplement to a high-molasses diet. Other research has confirmed this response by cattle when different sources of bypass protein have been included in molasses-based diets (see Preston and Leng 1987). It could be construed, therefore, that the protein in WCS was also largely undegraded in the rumen and that the animals responded to supply of this additional undegraded dietary protein in the intestines. This is supported by the fact that all supplements contained the same amount of nitrogen, with soluble nitrogen in the form of urea used to equilise nitrogen intake. Furthermore, with the inclusion of 3% urea in molasses, slightly in excess of theoretical requirements (Preston and Willis 1974), and additional nitrogen from cottonseed meal, it is unlikely that rumen degradable protein was limiting for optimum rumen microbial function. In fact, mean $NH_3$-N concentration in rumen fluid over 24 hours decreased with increasing WCS intake, presumably in response to a reduction in the amount of urea added to the straw. Values for all treatments exceeded the threshold (4 mM) set by Satter and Slyter (1974) for optimal rumen function.

In contrast to the above, Bird and Dicko (1987), using a forage-based diet, surmised that the protein of WCS is highly degraded in the rumen, which is supported by results from *in sacco* studies indicating protein degradability in the rumen of 74 to 77% (Utley and McCormick 1980; Arieli *et al.* 1989). The lower value of 50% was derived by Zinn (1995) in a study using dual-cannulated steers fed a grain-based ration including 15% WCS. It appears that the degradability of protein in WCS is not a constant but is dependent on the nature of the basal ration. Higher rumen bypass of WCS protein on molasses-based rations may be related to reduced rumination and physical degradation of WCS resulting in larger, less degraded particles passing from the rumen, although the absence of any whole seeds in the faeces indicates that some physical break-down did occur. Zinn (1995) showed that grinding of WCS prior to feeding increased ruminal protein degradability by 20%.

The response to WCS, at least at the highest intake, could alternatively, or additionally, be attributable to the effect of the fat component of the supplement. A growth response to the inclusion of oil in a molasses-based ration was recorded by Pate *et al.* (1995) although Lindsay *et al.* (1989) found no effect. Lofgreen and Otagaki (1960) suggested that the net energy value of molasses declined as the proportion of molasses in the ration increased. Provision of lipids in low-fat diets reduces the need for fat synthesis, and therefore presumably for the glucose required for glycerol synthesis and reducing equivalent generation. The growth responses with increasing WCS intake may therefore have been associated with increased glucose availability. However, the molar proportions of propionate, a major precursor of glucose, were within the 'normal' range and were not affected by intake of WCS.

Whereas some studies have demonstrated a reduction in protozoal ruminal concentration with inclusion of WCS specifically (Bird and Dicko 1987), and of fat in general (Ikwuegbu and Sutton 1982; Newbold and Chamberlain 1988), in forage-based diets, there was no such effect in our experiment when WCS intake increased from 200 to 1000 g/day. It appears that higher intakes of WCS are required to reduce protozoa numbers when the basal diet is molasses, perhaps because a substantial proportion of the oil passes out of the rumen in seed particles together with the protein (see above). Coppock *et al.* (1987) proposed that higher amounts of lipid could be fed as WCS than as free oil without affecting rumen function by virtue of the slow release of lipid from WCS during eating and rumination.

This study has indicated the potentially high production achievable from combinations of molasses and WCS, although the reasons for this apparent synergism have not been determined. If confirmed under practical feeding conditions of longer duration, it provides the framework for developing strategies for using high-molasses diets as an alternative to grain-based diets for finishing cattle.

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