# WHOLE COTTONSEED AND COTTONSEED MEAL SUPPLEMENTS FOR CATTLE GIVEN A HAY-BASED DIET

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## SUMMARY

This experiment investigated the extent to which whole cottonseed (WCS) could substitute for cottonseed meal (CSM) in a supplement for steers consuming low quality roughage. For 84 days, 60 group-penned weaner steers (154 kg) were fed Rhodes grass hay (8 g N/kg dry matter; DM) *ad libitum* either alone (control), or with isonitrogenous (*ca.* 31g/day N) combinations of CSM/WCS which, as g/day as fed, were 500/0, 375/250, 250/500, 125/750, 0/1000. Calculated on a percent of liveweight (LW) basis, hay DM intake was 2.1% LW for the control steers and this increased marginally ($P > 0.05$) when CSM was fed alone but declined when inclusion of WCS in the supplement exceeded 500 g/day (0.28% LW), so that hay intake for the group receiving 1000 g/day WCS was only half that of the controls ($P < 0.05$). Total DM intake followed a similar trend ($P = 0.06$) with the corresponding reduction in intake for the high WCS group being 21%. Steers receiving 250 to 500 g/day CSM had higher ($P < 0.05$) growth rates (average 0.47 kg/day) than those receiving no supplement (0.18 kg/day) or 1000 g/day WCS (0.14 kg/day), the latter treatments being not significantly different ($P > 0.05$). It is provisionally suggested that, in order to avoid production loss, the substitution of WCS for CSM in the supplement should adhere to two general rules: that the ratio WCS:CSM not exceed 2:1, and that total fat content in the ration not exceed 5% DM.

*Keywords*: cattle, growth, intake, cottonseed meal, whole cottonseed

## INTRODUCTION

Cattle grazing unimproved pastures in northern Australia often experience considerable liveweight losses during the drier winter/spring months of the year unless provided with dietary supplements to augment protein and energy supply (Winks 1984). One supplement widely used is cottonseed meal (CSM) which has been shown to arrest the weight losses and in some cases promote small weight gains in grazing cattle (Lindsay *et al.* 1990; S. McLennan, unpublished data). However, supply of CSM often becomes limited during extended droughts and alternative sources of protein and energy are required.

Whole cottonseed (WCS) is readily available commercially and is now being used quite extensively in the beef industry. It is a supplement of high fibre, high energy and moderately-high protein content (approximately half that of CSM) and is relatively palatable to cattle. However, there is at present limited information about appropriate levels of feeding, and in particular about the extent to which WCS could cost-effectively replace CSM in the supplement. In a pen study, Lindsay *et al.* (1988) reported no difference in growth rate of steers given either WCS (1000 g/day) or CSM (500 g/day), although the latter supplement also included urea. The results of Thompson and Dixon (1988) indicated that the combination of WCS and CSM was superior to WCS alone in promoting increased growth rate in non-pregnant mature cows. This experiment was set up to investigate the effects on animal performance of sequentially replacing CSM with WCS in a supplement for steers consuming a low quality hay.

## MATERIALS AND METHODS

### *Animals and experimental design*

Sixty Brahman x Shorthorn cross weaner steers were used. Steers were weighed unfasted and then fasted (after 24 hours without food and 16 hours without water), and the two weights were averaged, stratified and animals separated into a heavy (164; s.e. 1.2 kg) and a light (143; s.e. 1.5 kg) main group. The steers were then allocated to treatments by stratified randomisation on the basis of this averaged liveweight. The experimental design was a randomised block comprising two replicates of six treatments with five steers per cell, one replicate coming from each of the heavy and light strata. Treatment groups were randomly allocated to 12 large (70 $m^2$), concrete-floored outdoor pens at the Animal Husbandry Research Farm, Rocklea.

*Dietary treatments and experimental procedures*

Rhodes grass (*Chloris gayana*) hay was milled to approximately 2 to 3 cm lengths and fed *ad libitum* to the steers either alone or with various supplements in which CSM (screw-pressed) was progressively replaced by WCS (fluffy white), on an approximately isonitrogenous basis (*ca.* 31 g/day N). The supplements were: (i) Control - no supplement; (ii) 500C; (iii) 375C/250W, (iv) 250C/500W, (v) 125C/750W, and (vi) 1000W, where daily allowances (g/day, as fed) of CSM and WCS are indicated by the numbers preceding C and W respectively. Once daily (0800 hours), the hay was placed in the trough and the supplements added to the hay. The quantity of hay fed was adjusted daily for each pen to ensure, as far as possible, that most of the supplement was eaten but that hay intake by the steers was not limited at the same time. Additional hay was fed late in the day if required to ensure *ad libitum* intake. For determining intakes it was assumed that all the supplement was eaten. The first week was used as an equilibration period to gradually increase supplement intake. Residual food was collected and weighed once weekly. The dry matter (DM) contents of these residues and of the hay and supplements presented were determined weekly. The experiment continued for 84 days. Steers were weighed unfasted and fasted at the start and finish of the experiment and unfasted liveweights were recorded weekly.

*Statistical analysis*

Data were subjected to analysis of variance for a randomised block design using Genstat (1993) with the pen as the experimental unit. Differences between means were tested using the least significant difference procedure ($P = 0.05$). Liveweight changes over time were subjected to repeated measures analysis of variance (Genstat 1993).

## RESULTS

The hay, CSM and WCS contained, per kg DM, 8, 69 and 35 g N whilst the CSM and WCS contained 32 and 208 g fat. There was no replicate effect for any variable. The intakes of hay and total DM have been expressed in kg/day in Table 1, and as a percent of liveweight (% LW), relative to the corresponding intake of the control group, in Figure 1. Trends discussed below refer to the latter as these take account of changes in liveweight during the course of the experiment. Intake of hay by the control steers averaged 2.1% LW. Hay intake was depressed, relative to the control, when intake of WCS exceeded 0.28% LW (500 g/day), although significantly ($P < 0.05$; s.e. 0.17) so only at the highest rate (0.55% LW, 1000 g/day) of WCS intake (see Figure 1). There were no significant effects of treatment on total DM intake when expressed in proportion to LW, although the trend ($P = 0.06$; s.e. 0.18) was for an increase (26%) to feeding CSM alone but with incremental reductions in intake as WCS intake exceeded 0.28% LW (500 g/day; see Figure 1). Total DM intake for the 1000W group was 21% less than for the controls (LW basis).

Feeding CSM alone increased ($P < 0.05$) growth rate of the steers relative to the controls (Table 1) but the response was eroded as WCS intake exceeded 500 g/day, and treatments including 750-1000 g/day of WCS had similar growth rates to the control.

**Table 1. Intakes (kg/steer.day) of hay, cottonseed meal (CSM), whole cottonseed (WCS) and total DM, and liveweight (LW) gain (kg/day), of steers fed treatment diets (details in text) for 84 days**

| | Control | 500C | 375C/250W | 250C/500W | 125C/750W | 1000W | s.e.m. [A] |
|---|---|---|---|---|---|---|---|
| *DM intake* | | | | | | | |
| Hay | $3.40^{ab}$ [B] | $4.06^{a}$ | $3.68^{a}$ | $3.44^{ab}$ | $2.53^{bc}$ | $1.72^{c}$ | 0.26 |
| CSM [C] | | 0.47 | 0.31 | 0.23 | 0.12 | | |
| WCS | | | 0.23 | 0.48 | 0.69 | 0.85 | |
| Total | $3.40^{bc}$ | $4.53^{a}$ | $4.22^{ab}$ | $4.15^{ab}$ | $3.34^{bc}$ | $2.58^{c}$ | 0.28 |
| *LW gain* | $0.18^{b}$ | $0.47^{a}$ | $0.45^{a}$ | $0.48^{a}$ | $0.33^{ab}$ | $0.14^{b}$ | 0.06 |

[A] s.e.m. is standard error of the mean.
[B] Means in the same row with different superscripts are significantly different ($P<0.05$).
[C] Intakes of CSM and WCS were not statistically analysed.

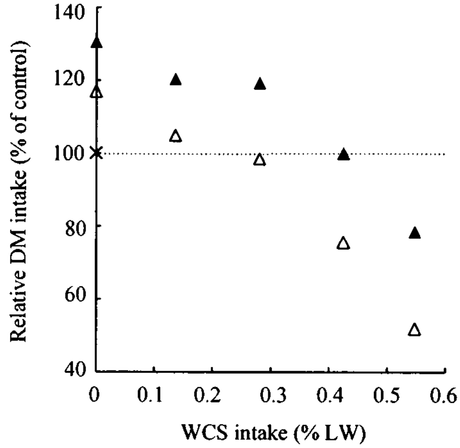


**Figure 1. Effect of intake of whole cottonseed (WCS) on the intake (% liveweight; LW) of hay (open symbols) and total (closed symbols) DM by supplemented steers, expressed relative to the intake of the control group (X; hay and total DM intake 2.1% LW). Values for hay and total DM intake shown on the Y axis represent group 500C.**

## DISCUSSION

The increased growth rate of steers resulting from feeding CSM in this experiment was consistent with previous findings from other pen studies using a similar low quality hay. McLennan *et al.* (1996) fed increasing amounts of CSM to young steers and reported a curvilinear (asymptotic) response curve in which growth rate plateaued out when intake of CSM reached about 1% LW. In a similar experiment (McLennan and Poppi 1995), growth rate of steers had not peaked at the highest level of CSM feeding of 1.5 kg/day, equivalent to 0.9% LW. It is likely, therefore, that feeding higher levels of CSM in the present experiment would have resulted in further increases in growth rate since 500 g/day was equivalent to only 0.3% LW.

It appears that WCS can be substituted for CSM in a supplement only at moderate levels of inclusion without causing production losses. Growth rate was unaffected until intake of WCS exceeded 500 g/day, with a significant reduction when intake reached 1000 g/day. This depression in growth rate at the highest level of feeding meant that growth rate was not different for this treatment compared with that of the unsupplemented control. These growth rate effects reflected parallel changes in the intake of hay and total DM. Compared with the group receiving 500 g/day CSM, that receiving an isonitrogenous amount of WCS (1000 g/day) had a 55% lower hay and a 40% lower total (non-significant) DM intake on a liveweight basis. Furthermore, total DM intake for the 1000W group was 21% lower than for the control despite achieving similar growth rate. However, the energy density of the diet containing WCS would have been considerably higher than for the control ration, by virtue of the high fat content in the WCS. In fact, when intake of metabolizable energy (MEI) was estimated by assuming ME contents for hay and CSM of 6.7 and 11.6 MJ/kg DM respectively (S. McLennan, unpublished data) and for WCS of 13.6 MJ/kg DM (NRC 1996), and corrected for metabolic liveweight (kJ/kg $W^{0.75}$/day), it was closely correlated with average daily gain (ADG; kg/day) of the steers, according to the equation: ADG = -0.853 + 0.002 MEI; ($r^2 = 0.99$). Thus supplements changed ME intake, not the efficiency of utilisation of that energy (eg $k_f$). Coppock *et al.* (1985) reported a similar (linear) decline in total DM intake, with no decrease in calculated intake of net energy for lactation, as intake of WCS by cows increased from 0 to 30% of the total ration.

Providing additional nutrients to ruminants as supplements often results in reduced intake of the forage component of the diet, ie substitution, with the reduction in forage DM intake usually equal to, or less than, the intake of supplement (Schiere and de Wit 1995). Our results differed from this general situation in that hay DM intake declined at a greater rate (from 2.41 to 1.07% LW) than supplement DM intake increased (from 0.28 to 0.55% LW), indicating an inhibition of, rather than substitution for, hay intake as WCS intake increased. Consequently, total intake decreased in parallel with hay intake (see Figure 1) whereas it would generally be expected to increase or at worst remain constant with increasing supplement intake (Schiere and de Wit 1995). A probable inhibitory component of the WCS was its high fat content. Previous findings have suggested that nutrient intake and digestibility will be depressed when more than 5% fat is incorporated in high-roughage ruminant diets (Orskov *et al.* 1978; Moore *et al.* 1986), apparently due to a reduction in numbers of cellulolytic rumen microorganisms or an inhibition of their activity (Devendra and Lewis 1974). In our experiment, the estimated fat contents in the diets were 0.3, 1.4, 2.6, 4.4 and 6.9% DM respectively, as WCS intake increased incrementally from 0 (500C) to 1000 g/day, and the depression in hay intake was thus apparent at quite low fat inclusion rates. Our results also closely align with those of Brosh *et al.* (1989) who found that intake of digestible nutrients was optimised when the proportion of WCS in the diet was 12% of DM. In our experiment, the corresponding proportions of WCS in the diet were 5.5, 11.6, 20.7 and 32.9% (see Table 1) as intake increased from 250 to 1000 g/day, with perfomance declining when the proportion exceeded 11.6% (500 g/day WCS). It cannot be discounted that some other factor, perhaps gossypol, was involved at some level in these effects on intake, especially as the steers were still quite young, but we have no data to support or discount this possibility.

Based on the present results we suggest that, for optimising animal growth, the level of inclusion of WCS in supplements should adhere to two general rules, namely that the fat content in the total diet not exceed 5% of total DM intake and that, where used to replace CSM, the ratio of WCS:CSM should not exceed 2:1. Least-cost ration formulation should then determine the appropriate combination of the two supplements within these general boundaries. Absolute intakes of supplement (kg/d) will depend on various factors, including the quality of the basal diet, liveweight of the animals and the growth rate targeted. Further work is required to investigate these proposals across a range of production systems, including across a range of ages of cattle.

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**REFERENCES**

BROSH, A., HOLZER, Z. and LEVY, D. (1989). *Anim. Prod.* **48**, 513-8.

COPPOCK, C.E., WEST, J.W., MOYA, J.R., NAVE, D.H., LaBORE, J.M., THOMPSON, K.G., ROWE, L.D. and GATES, C.E. (1985). *J. Dairy Sci.* **68**, 2248-58.

DEVENDRA, C. and LEWIS, D. (1974). *Anim. Prod.* **19**, 67-76.

GENSTAT (1993). 'Genstat 5 Release 3 Reference Manual'. (Genstat 5 Committee: Harpenden, UK).

LINDSAY, J.A., MULLINS, T.J. and KIDD, J.F. (1988). *Proc. Aust. Soc. Anim. Prod.* **17**, 432.

LINDSAY, J.A., KIDD, J.F., KENDALL, I.E., GELLING, B.A. and MAYER, R.J. (1990). *Proc. Aust. Soc. Anim. Prod.* **18**, 514.

McLENNAN, S.R. and POPPI, D.P. (1995). *Ann. Zootech.* **44**, (Suppl.), 358.

McLENNAN, S.R., KIDD, J.F., POPPI, D.P., CONNELL, J.A., BOLAM, M.J. and BLIGHT, G.W. (1996). *Proc. Aust. Soc. Anim. Prod.* **21**, 495.

MOORE, J.A., SWINGLE, R.S. and HALE, W.H. (1986). *J. Anim. Sci.* **63**, 1267-73.

NRC (1996). 'Nutrient Requirements of Beef Cattle'. 7th Revised Edition. (National Research Council: Washington, D.C.).

ORSKOV, E.R., HINE, R.S. and GRUBB, D.A. (1978). *Anim. Prod.* **27**, 241-5.

SCHIERE, J.B. and De WIT, J. (1995). *Anim. Feed Sci. Technol.* **51**, 45-63.

THOMPSON, R.J. and DIXON, I.W. (1988). *Proc. Aust. Soc. Anim. Prod.* **17**, 474.

WINKS, L. (1984). Australian Meat Research Committee Review **45**, 1-43.