CELLULOLYSIS AND UREA IN MOLASSES BASED DIETS

D. FFOULKES,* GAYE KREBS,* and T. M. SUTHERLAND*

Molasses based diets for cattle have been successfully developed for production systems, and are widely used especially in countries associated with sugar production (Preston 1972; Preston and Willis 1974). However, the feeding of high levels of molasses to ruminants requires an understanding of the specific characteristics of molasses, which are:

a) That a large proportion of the energy is in the form of sugars which 'are rapidly fermented in the rumen (Marty and Sutherland 1970),

b) That it contains most major and minor mineral nutrients, except phosphorus, sodium (which is required to offset the high concentrations of potassium present) and sulphur,

c) The absence of roughage characteristics,

c) And the provision of only small quantities of N (present mainly as free amino acids).

Molasses, when fed to maximize the growth of cattle, is given to appetite in a mixture containing urea (normally 3% w/w) and minerals, in particular, sodium chloride and usually calcium dihydrogen orthophosphate to supply phosphorus (These supplements are best mixed with equal parts of water before mixing with molasses) and the roughage component of the diet is restricted to 1% (as DM) of liveweight. The full growth potential of the animal cannot be met by microbial protein synthesis alone and therefore a protein supplement, which is resistant to rumen fermentation is added to the ration. Silvestre et al. (1977) and Ffoulkes and Preston (1978) have reported growth rates ranging from 735 to 860 g/d for 200 kg Zebu bulls on such molasses fattening rations, and similar growth rates were observed by Kempton (1981).

In many parts of Australia, one of the main constraints for cattle production is the availability of forage during the dry season or in drought. The advantage of molasses based diets is the low requirement of roughage, and therefore molasses could be useful to graziers as a basis for a number of possible feeding strategies in drought conditions.

The purpose of this study was to look at molasses (without protein supplementation) as a survival feed, and then to examine the response of cattle to a molasses based fattening diet after a period at survival level. At the same time, parameters of rumen function were studied in cattle on molasses diets with and without supplementation with urea, protein and starch, and a comparison was made with forage based diets.

EXPERIMENTAL

Two types of experiments were set up: the measurement of animal performance was carried out as a growth trial in a feedlot, and studies on rumen function were done indoors on rumen fistulated cattle.

* Department of Biochemistry and Nutrition, University of New England, Armidale. 2351. Australia.

Expt 1: Growth Trial

36 Hereford weaners (average weight of 138kg) were divided into 4 groups after vaccination and drenching. Three of the groups contained 4 steers and 5 heifers, while the fourth had 3 steers and 4 heifers. The basal diet consisted of free choice molasses and wheaten straw (4% CP) which was fed at 0.8% (DM basis) of liveweight. Minerals were mixed into the molasses.

The first period of the experiment measured the performance of animals on the basal diet supplemented with urea at a rate of 0, 1, 2 and 3% in molasses (w/w). In the second period, the dietary treatments were the same except that each group received daily 0.5 kg per animal of protein meal (80% cottonseed and 20% meat meal).

After 99 days a period of intense rain made conditions in the feedlot unmanageable and the animals were put on poor pasture for 3 weeks, while the feedlot was prepared for the commencement of the second molasses feeding period. Throughout the experiment all animals were weighed once a week.

Expt 2: Rumen Observations

8 rumen fistulated steers weighing approximately 250kg were used in replicated 4 x 4 Latin square design to study rumen function on molasses based (Expt A) and forage based diets (Expt B), with and without supplementation. The dietary treatments for each basal diet were:

Experiment:		A	B
Treatment:	1.	Molasses ad libitum	4 kg Oaten Chaff
	2.	+ urea (3% w.w)	+ urea (3% of OM)
	3.	+ urea + 200g Fishmeal + 100g Maize gluten	+ urea + 400g Fishmeal + 150g Maize gluten
	4.	+ urea + 200g Fishmeal + 1kg Cracked maize	+ urea + 400g Fishmeal + 1kg Cracked maize.

The protein content of Treatment 3 was balanced with Treatment 4 by adding maize gluten. Minerals were added to all dietary treatments.

Animals were adapted to the molasses based diet for one month prior to the start of Expt A. Each period of the Latin square was 3 weeks and the parameters of rumen function were recorded to in the last week of each period. Animals were allowed 30 days to adapt to the forage based diet used in the second experiment.

One of the parameters of rumen function measured was the rate of cellulose digestion. This was done by suspending Dacron bags containing absorbent cotton wool or wood cellulose (Solka Floc) in the rumen, and recording the DM of material remaining after 12, 24, 48 and 72 h. The nitrogen content of the samples remaining in the bags were also determined in order to correct for bacterial colonization of the cellulose. Other parameters recorded were the concentrations of rumen metabolites and protozoa. Rumen fluid kinetics were measured by using Cr-EDTA as a soluble chromium indicator in a method described by Downes and McDonald (1964).

RESULTS

Experiment 1 : The liveweight change of each group of animals for the whole period of the growth trial is given in Figure 1. After 70 days on the molasses based diet without protein supplementation, the mean weight of animals receiving 1% urea in molasses was significantly better by 6% than those receiving molasses without urea. At 93 days, this latter group weighed 155 kg ($p<0.05$) compared with those receiving 0, 2 and 3% urea which weighed 139, 146 and 142 respectively. (Table 1).

Three animals died in the experiment; one from the 1% urea group (88th day) and two from 0% urea group (99th day). It is thought that at least two of these deaths were attributable to a combination of cold temperatures and deterioration of the condition of the feedlot due to rain, as no definite causes could be diagnosed in the autopsy.. The third animal may have died from bloat.

All groups kost considerable weight during the period of 3 weeks on pasture (99 - 119 days). When animals were returned to the feedlot, all groups which had been supplemented with urea had the same mean weight (139 kg), and the group which did not receive urea was significantly lighter by 11 kg. There were no treatment differences in the growth rate (645 - 773 g/d) of animals during 44 days of measurement when protein supplement was included in the ration.

Experiment 2: The results for the parameters of rumen function are given for treatments on the molasses based diet in Table 2. Rumen fluid volume and flow rate tended to be smaller and molasses intakes were signigicantly lower when animals did not receive urea.

The measured metabolites of rumen fluid were ammonia total concentrations of Volatile Fatty Acids (VFA) and the molar proportions of acetate, propionate and butyrate. There was a marked difference in rumen ammonia levels between supplemented and unsupplemented diets. The proportion of acetate increased with level of supplementation and butyrate was highest when urea was not present in the molasses. Addition of fishmeal appeared to increase the concentration of propionate in rumen fluid.

Rumen protozoa1 numbers were generally low and there was great variation between animals within treatments.

The DM loss of absorbent cotton wool from rumen bags is illustrated in Figure 2 for molasses and forage based diets. Between 7.5 and 10.0% of the DM was apparently digested after 48 h in animals on supplemented molasses compared with no apparent digestion of cellulose occurring on the control diet. Cellulose was digested very slowly on molasses based diets compared with forage based diets, which gave apparent digestibilities of 70% of the cotton wool.

DISCUSSION

The growth trial reported here indicates that a level of performance around maintenance can be obtained with molasses alone with restricted forage; that addition of urea in the molasses increased molasses consumption and weight gain; but that protein supplementation was necessary to give high weight gains. The gains on protein supplementation are similar to those observed by Ffoulkes and Preston (1978), Silvestre et al. (1977) and Kempton (1981). There seems to be no benefit, either with or without protein supplementation, in raising the molasses concentration of urea above 1%. Silvestre et al. (1977) claimed a linear response in growth rate to increase urea concentration up to 4% but closer examination of the data reported shows high between group variability in growth rate. The

Table 1: Molasses intakes and performance of weaners on molasses diets and forage (1% of LWT), with different levels of urea and protein supplementation.

Protein, kg	0				0.5			
Urea level, %	0	1	2	3	0	1	2	3
No. of days	-93-				-51-			
Initial wt, kg	137	139	137	138	126	138	137	137
Final wt, kg	139	152	146	142	160	177	173	170
Growth, g/d	23	143	100	45	645	773	698	645
Molasses intake, kg/h/d	2.1	2.5	2.5	2.6	3.0	3.2	3.4	3.8
Feed conversion	96	9	13	57	6	5	6	6

Table 2: Effects on rumen kinetics, metabolites and cellulose digestion in cattle on molasses based diets (oaten chaff at 1% Lwt), of supplemented with urea (3% ww), urea (3%) and fishmeal (250 g), or urea (3%), fishmeal and cracked maize (1 kg).

Diets:	Basal	+ Urea	+ Urea Fishmeal	+Urea Fishmeal Maize
Rumen kinetics:				
Volume, l	51.5	62.6	66.9	67.3
Flow rate, l/d	88.3	111.6	115.1	109.2
Rumen NH_3, mg N/l	6.6	119.6	118.9	114.7
VFA, molar %:				
Acetate	44.2	50.7	53.6	61.3
Propionate	12.2	12.6	15.5	15.1
Butyrate	41.0	30.1	26.6	21.4
Total conc, mmol/ml	91.1	99.8	102.4	87.1
Protozoal No. (x 10^{-5})*	1.3	0.2	0.3	2.0
Cellulose disappearance rate: % DM/48 h	0.8 (68)	8.7 (69)	7.5 (71)	10.3 (78)
Molasses intake, kg DM	4.0	5.5	5.3	5.0

* Entodinia
Bracketed values refer to a forage based diet.

results of Ramirez and Sutherland (1971) where there is a clear increase in molasses intake up to 4% urea, are against a diet base when forage or grain were offered ad libitum. Gulbransen (1981) recently examined the effect of urea addition at 3% to molasses, but with restricted molasses intakes of 0.8 and 1.3 kg of molasses per 100 kg bodyweight/day. He obtained about 100 g/d less weight loss through urea addition.

In the experiments with fistulated animals, the very low rumen NH_3 levels in animals withouturea supplementation would be. at a level to limit microbial growth and so animal performance and intake (Satter and Slyter 1974; Miller 1973; Kowalczyk et al, 1969, 1970; Chicco et al, 1972).

The results of the experiments on cellulolysis using the Dacron bag technique show an enormous decrease in rate during molasses feeding experiments compared with that during the forage feeding period. With these slow rates of cellulolysis, when molasses is fed, appreciable fibre will accumulate in the rumen even at low rates of forage intake, so that daily forage requirements to maintain rumen motility especially if the quality of forage is not high, may be very low indeed. Gulbransen's observations, that he could keep animals for 22 weeks on molasses alone, suggest that the forage requirement was very low when molasses intake is low, or that at sub-maintenance levels on liquid diets, a physical stimulus to rumen contractions is unnecessary.

Figure 3 shows the relationship between molasses intake on performance for the results reported here and those of other workers. For all but the experiments of Gulbransen (1981), the results are for molasses intakes to appetite, control being exerted by protein level or urea level. It would be interesting to pursue this further and extend the range of molasses intake which can be controlled by removal of nutrients. The present experiment and those of Preston and his co-workers (Preston 1972; Preston and Willis 1974; Munoz et al, 1970) indicate that any level of performance from maintenance to 850 g/d can be obtained on molasses systems in which the forage intake is restricted. The effects of forage removal on molasses intakes in diets of molasses alone and molasses with urea, needs to be more fully examined.

The removal of forage has been claimed to precipitate "molasses toxicity" (Losada et al, 1971; Rowe et al. 1979) but Beveridge and Leng (1981) saw no problems 20 days after forage removal, and Gulbransen (1981) reports only a single case in his experiments which involved forage withdrawal for 22 weeks.

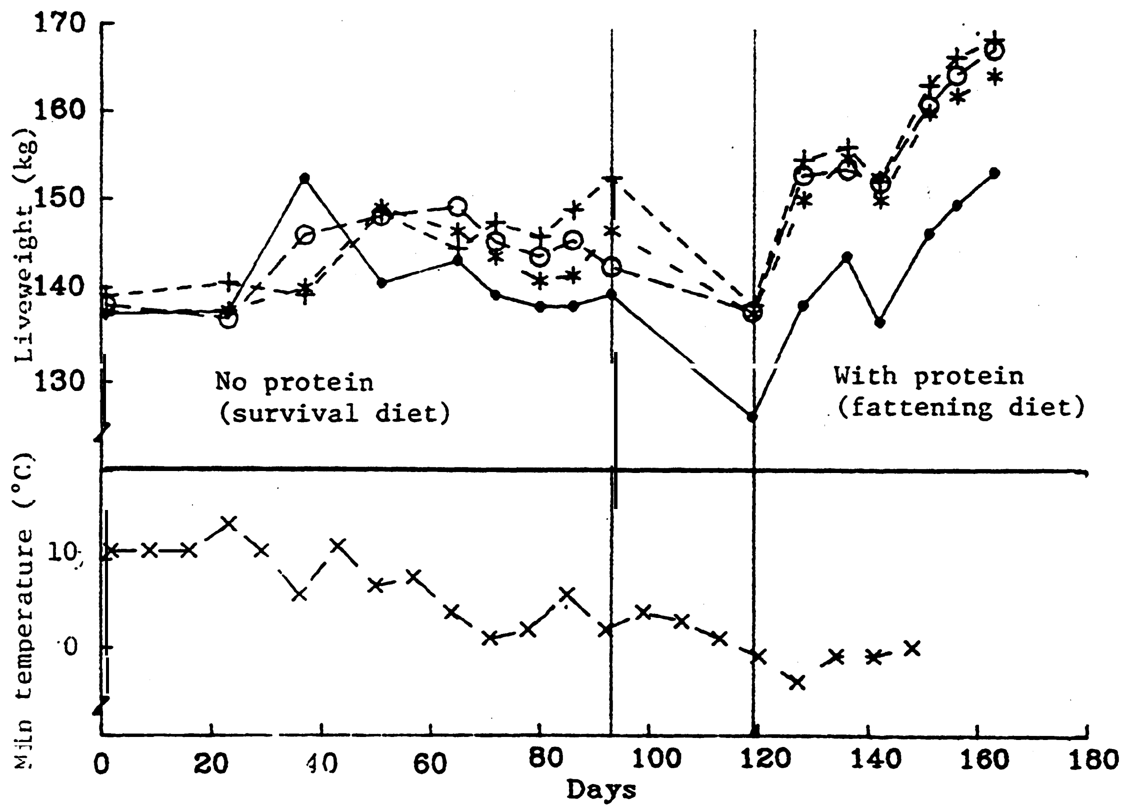

Fig. 1 Live weight of weaners on molasses supplemented with 0 (•), 1 (+), 2 (0) and 3 (*)% urea

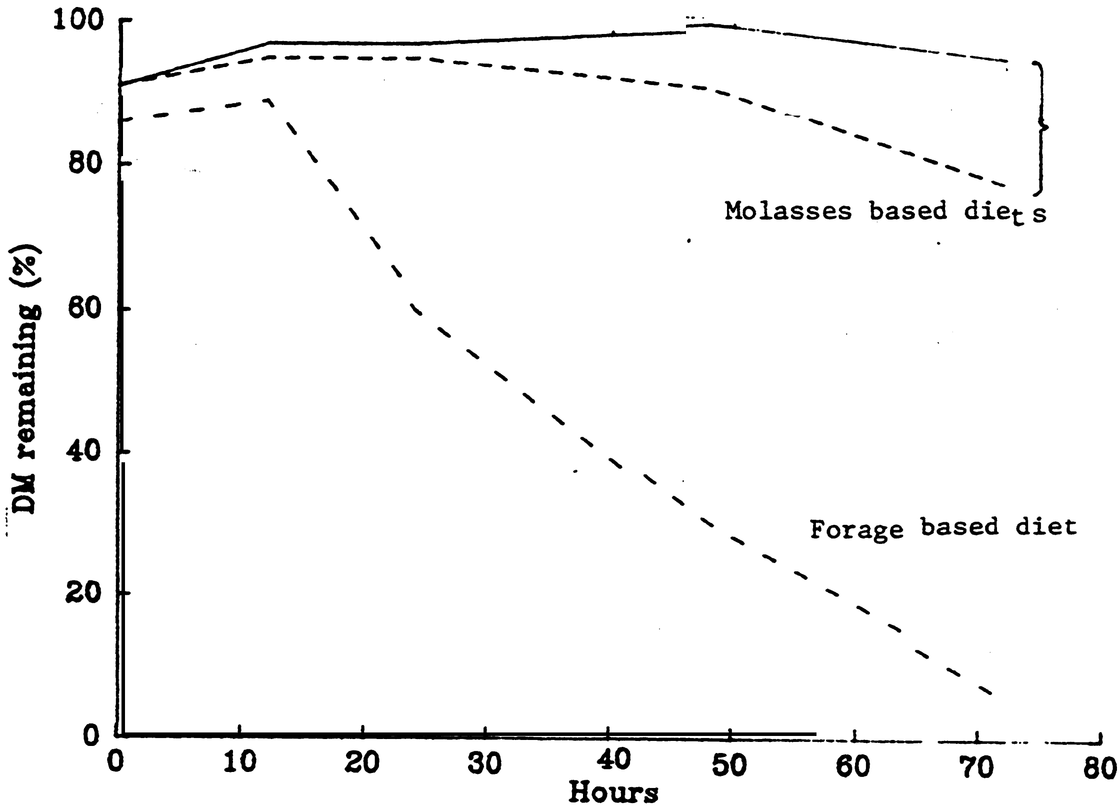

Fig. 2 Disappearance of cottonwool from rumen bags (—— without urea; - - - with urea)

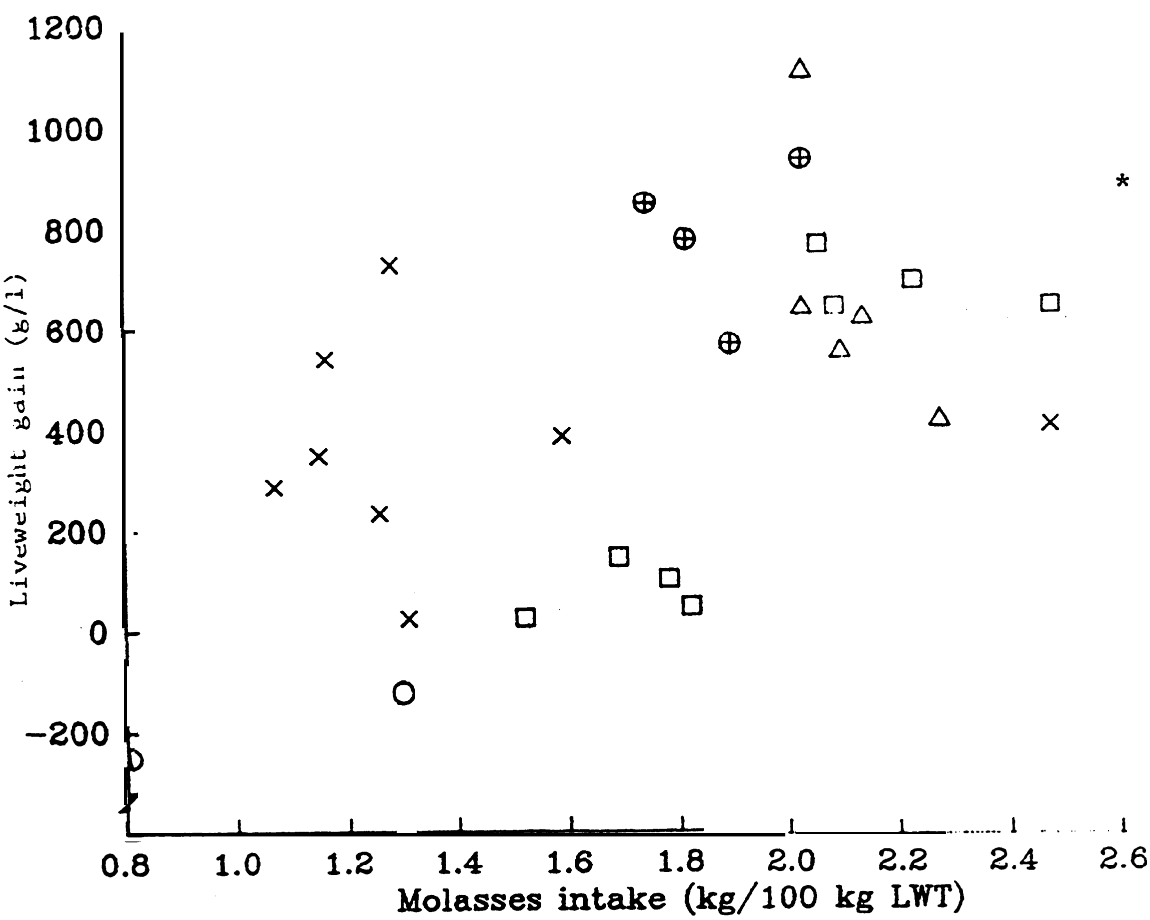

Fig. 3 Relationship between molasses intake and performance

O Gulbransen (1981)
X Silvestre et al. (1977)
⊕ Ffoulkes and Preston (1978)
□ This paper
Δ Kempton (1981)
* Muñoz et al. (1970)

REFERENCES

BEVERIDGE, R.A. and LENG, R.A. (1981), Trop. Anim. Prod. 6: 5-9.
CHICCO, C.F., SHULTZ, T.A., SHULTZ, E., CARNEVALI, A.A. and AMMERMAN, C.B. (1972), J. of Anim. Sci. 35: 859-864.
DOWNES, A.M. and McDONALD, I.W. (1964), Br. J. of Nutr. 18: 153-162.
FFOULKES, D. and PRESTON, T.R. (1978), Trop. Anim. Prod. 3: 186-192.
GULBRANSEN, B. (1982), Proc. Aust. Soc. Anim. Prod. 14: 606.
KEMPTON, T.J. (1981), In "Recent Advances in Animal Nutrition in Australia 1981" (D.J. Farrell, editor) abs. 10A.
KOWALCZYK, J., RAMIREZ, A and GEERKEN, C.M. (1969), Rev. cubana Cienc agric. (Eng. ed.) 3: 221.
KOWALCZYK, J., RAMIREZ, A. and GEERKEN, C.M. (1970), Rev. cubana Cienc agric. (Eng. ed.) 4: 187.
LOSADA, H., DIXON, F. and PRESTON, T.R. (1971), Rev. cubana Cienc agric. (Eng. ed.) 5: 369.
MARTY, R.J. and SUTHERLAND, T.M. (1970), Rev. cubana Cienc agric. (Eng. ed.) 4: 45.
MILLER, E.L. (1973), Proc. Nutr. Soc. 32: 79-84.

MUÑOZ, R., MORCIEGO, F. and PRESTON, T.R. (1970), Rev. cubana Cienc agric. (Eng. ed.) 4: 91.
PRESTON, T.R. (1972), World Rev. of Nutr. & Diet. 17: 250-311.
PRESTON, T.R. and WILLIS, M.B. (1974), Intensive Beef Prod. Oxford, Pergamon Press.
RAMIREZ, A. and SUTHERLAND, T.M. (1971), Rev. cubana Cienc agric. (Eng. ed) 5: i85.
ROWE, J.B., BOBADILLA, M., FERNANDEZ, A., ENCARNAÇION, J.C. and PRESTON, T R. (1979), Trop. Anim. Prod. 4: 78-89.
SATTER, L.D. and SLYTER, L.L. (1974), Br. J. Nutr. 32: 199-208.
SILVESTRE, R., MacLEOD, N.A. and PRESTON, T.R. (1977), Trop. Anim. Prod. 2: 315-318.