# MOLASSES AS A DROUGHT FEED

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Drought is a recurring feature of the Queensland pastoral scene and has a dramatic impact on production. From the national point of view, the major aim of any drought mitigation policy must be to ensure the survival of a nucleus of breeding livestock at minimum cost. However, individual producers have to decide at some time whether to sell part or all of their herd or to feed them. If they decide to feed, they have traditionally used grain or hay. However, molasses is a cheap source of energy, rich in sulphur, though grossly deficient in nitrogen (Wythes et al. 1978).

For many years, molasses was used principally as a carrier for urea supplements during the winter dry season (Winks 1984). Urea/molasses was usually fed in drum lickers. It was necessary to commence feeding before cattle began to lose weight; capital, labour and freight costs were high; lickers required frequent filling to ensure a continuity of supply and occasional deaths occurred due to urea toxicity.

In the recent drought years (1979-83) in Queensland, molasses was fed as a major source of energy in the diet. Urea was added to provide rumen degradable nitrogen and at higher levels (c. 8%) to restrict intake, with some mixtures also including protein meal to provide non degradable nitrogen. These mixtures are collectively known as 'fortified molasses' (FM) and are intended to provide a survival ration. The molasses can be handled in bulk quantities from the sugar mill to the paddock where FM is fed in open troughs. We estimated that at least 1 m cattle were fed in this way at some time in 1982-83.

In view of the success and popularity of the FM system, it is timely to review the research on molasses feeding and to document the field experiences, problems and costs of using FM mixtures. It is pertinent also to review the situation and problems in relation to the demand, distribution and storage of molasses supplies. We hope that the knowledge and experience gained in the recent drought will benefit producers in future droughts.

## EXPERIMENTATION WITH MOLASSES AS A DROUGHT FEED FOR CATTLE

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The main principles involved in survival feeding are well known and have been summarized by Morris (1968). It is interesting to note, however, that Morris did not even mention molasses as a potential drought feed, but in 16 years it has become a widely used drought feed in Queensland. The role of research in this change, both in the field and on research stations, has largely been to adapt a known technology to a different feedstuff.

In a drought the rate at which an animal loses live weight (LW) depends on the balance between nutrient supply and requirements, and hence on the animal's size and physiological state. Its initial body reserves and the rate of LW loss together determine its survival time. In most drought situations the grazing animal has two sources of nutrients which contribute towards its performance, paddock roughage and a supplement. In practice only the supplement can be manipulated to modify performance and the performance level required should be the main criterion governing the quantity of energy (molasses) fed.

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Producers need information so that they can choose between possible feeding strategies. They need to know the levels of animal performance consistent with particular objectives such as survival, conception, pregnancy and calf rearing. They also need to know the minimum nutrient requirements to achieve these performance levels and how well alternative feedstuffs supply these requirements. Current research is broadly aimed at providing this information, It is best carried out in pens, where feed inputs are readily controlled and measured, because in paddocks pasture intake is largely unknown. Requirements established in this way generally represent the practical upper limits of hand feeding (with allowance for the energy cost of activity), since paddock feed normally makes some contribution to the animal's diet. Research in the grazing situation has sought to measure responses by different classes of cattle to different types and quantities of supplement.

In an effort to show the variety of current research, I propose to discuss briefly the results of a range of selected projects carried out by the Queensland Department of Primary Industries (QDPI),

Dry cattle Steers and non-pregnant, non-lactating females have less stringent nutritional requirements than other classes of cattle, so they have often been used in exploratory experiments, even though they generally receive least attention during drought. Some of the earliest relevant work was that of Beames (1960). He showed that heifers increased their consumption of poor quality hay when the concentration of urea was progressively increased from 0 to 33% in a molasses supplement. However, they reduced their intake and rate of consumption of the molasses mixture, maintaining a reasonably steady intake of urea. Manipulation of molasses intake by varying the concentration of urea is now widely recommended in the field. Beames' work also showed that cattle on diets of poor quality roughage can safely consume large quantities of molasses/urea.

Current pen feeding work has concentrated on energy and nitrogen inputs, since early work (Gulbransen unpub. data) showed there was no response to a complex mineral mix by cattle fed a molasses based diet at a sub-maintenance level.

Gulbransen (1983a) demonstrated that the LW loss of heifers (mean LW 247 kg) was reduced by increasing the amount of molasses fed (-0.25 and -0.12 kg/d for 2.0 and 3.2 kg molasses/d respectively) and by including 3% urea in the molasses (-0.22 vs - 0.11 kg/d). Molasses toxicity was not a problem even in the absence of roughage. The inclusion of 0.3 kg roughage/d and the dilution of the molasses with water did not affect LW. The experiment lasted for 23 wk and demonstrated that cattle can survive for long periods on diets consisting almost solely of molasses.

In another experiment (Gulbransen 1983b), steers (mean LW 193 kg) were fed for 11 wk on rations ranging from molasses/urea (3%) alone to 40% molasses/urea and 60% sorghum grain at rates equivalent to 1.5 or 3.0 kg of molasses/urea/d. The mean LW losses were -0.49 kg/d at the low level of feeding and -0.17 kg/d at the high level. Within feeding levels, molasses/urea was substituted for sorghum grain in the ratio 1.2:1 on a DM basis.

Weaners and calves During drought it is desirable to wean calves younger than normal to remove the stress of lactation from their dams, but it is necessary to supplement or fully hand feed these calves to ensure their survival. Molasses can be used as the basis for their diets, since Gulbransen (unpub. data) showed that calves as young as 5 wk can be successfully weaned onto a diet of 70% molasses, 10% meat and bone meal (MBM) and 20% lucerne chaff. These calves gained weight at 0.09 kg/d, while 10 wk old calves gained at 0.22 kg/d. A source of true protein appears to be necessary for such young animals.

In a grazing study in northern Queensland, McLennan et al. (1984) fed supplements of molasses/urea with and without MBM for 25 wk during the dry season to weaner heifers (mean LW 136 kg) grazing spear grass (Heteropogon contortus). The heifers were fed 0.96 kg molasses, 27 g urea, and 0.20 kg MBM/d twice weekly for the first 16 wk, but thereafter daily because each feed was eaten in less than 24 h. The unsupplemented heifers lost 16 kg LW while the molasses/urea group gained 7 kg and the molasses/urea/MBM group 28 kg.

Breeding females Pregnant and lactating females are more susceptible to drought than any other class of cattle and experimental work is currently concentrating on aspects of their management. In the dry tropics the digestibility and nitrogen content of pastures fall rapidly during the dry winter-spring and cattle lose considerable LW despite having an abundance of feed (Winks 1984). Lindsay et al. (1982) have shown that in this situation supplements of protected protein can produce large improvements in roughage intake, cow performance and calf birth weight. It is likely that pregnant and lactating females will also respond to protected protein fed as a supplement to molasses, and McLennan (unpub. data) has examined this with cows grazing spear grass pastures in northern Queensland. The cows were in store body condition(mean LW 284 kg) and had 8 to 14 wk old calves. The cows had lost an average of 35 kg LW in the 3 wk prior to supplementary feeding and were supplemented for 16 wk. Mean daily intakes of supplements were as follows (1) 0.6 kg MBM, (2) 2.5 kg molasses + 120 g urea, (3) 2.8 kg molasses + 140 g urea + 0.25 kg MBM. Cow LW changes for the period were -16.0 kg, -7.5 kg, and -4.0 kg respectively, while calf LW changes were 39.0 kg, 46.5 kg, and 49.0 kg.

In another experiment Gulbransen (unpub. data) fed cows (mean LW 310 kg, condition score 3.6 on an 8 point scale) and heifers (mean LW 250 kg, condition score 2.6) in pens on diets ranging from 3.0 kg/d of molasses/urea (3%) to 6.0 kg/d of molasses/urea (1.5%)/CSM (13%). The diets had no roughage component and were fed for 26 wk commencing 14 wk prior to the anticipated calving dates. After 9 wk the rations of most low level treatments were increased to 6.0 kg/d to prevent excessive LW losses and deaths. Only in treatments fed 4.5 or 6.0 kg/d of molasses/urea/CSM did the LW of the dam plus foetus increase up to calving, but even in these treatments calf birth weights were severely reduced. At all levels of energy intake, LW changes and survival rates of cows and calves were markedly improved by the inclusion of CSM.

It is clear that molasses/urea alone cannot provide the protein needed to produce satisfactory performance by pregnant and lactating females or calves, but it is a suitable source of energy. Depending on the dietary contribution of pasture, the addition of protected protein may produce worthwhile survival responses.

Since the feeding of molasses/urea in open troughs has become widespread, occasional deaths of cattle from urea toxicity have occurred following rain. Investigations by Gulbransen (unpub. data) show that failure to dissolve fully the urea in the molasses is the most likely predisposing factor, because it leaves a crust of urea on the surface. Well prepared mixtures are very stable, but they too can give rise to dangerous solutions in residual rainwater, depending mainly on the concentration of the molasses/urea solution and the time following rainfall. By way of example, 6 h following 25 mm of rainfall on molasses containing 8% dissolved urea the residual water layer could be expected to contain about 0.6% urea. This is more than twice the concentration presented in water troughs by urea dispensers used in the sheep industry, and is probably enough to cause deaths of cattle in many circumstances.

Conclusion In recent years the role of molasses in cattle feeding in Queensland has undergone a dramatic change. From being virtually a carrier for nitrogen and mineral supplements it has become a basic energy source in most drought feeding rations. It has an advantage compared with other concentrated sources of energy such as grain, in that it appears to be less rapidly consumed, thus reducing the effects of social dominance on intake of the supplement (Ernst 1973). When supplemented with urea and protected proteins, molasses can provide diets suitable for all classes of cattle and for a wide range of animal performances.

## FORTIFIED MOLASSES SYSTEMS FOR BEEF PROPERTIES

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A successful drought feeding system must be effective, flexible and simple, with low labour and capital costs. The experiences gained suggest that FM fulfils these factors to a greater extent than the previous system based on drum lickers (DL).

The drought management and feeding options on beef properties in relation to LW change for lactating cows are depicted diagrammatically in Fig. 1. The differences between the DL and the FM systems are also shown. DL feeding should start early (A) and in an energy drought it will have to be curtailed at some point on line AC. The 'do nothing' line from A to B denotes the strategy of graziers who do not usually feed until poverty deaths occur in cows. From recent field experiences, FM offers such graziers an alternative effective and flexible survival feeding system to grain or hay feeding. They do not need to sell their cattle, but can start to feed FM at any point along line AB. Three of the more popular combinations of molasses and nitrogen sources are shown in Fig. 1, together with the daily levels commonly fed to lactating cows and the resultant LW changes.

3% urea mix Preston (1972) suggested that 3% urea (U) weight by weight (w/w) of molasses provided sufficient nitrogen for complete fermentation when molasses is the major energy source and roughage is restricted. Early development of the FM system used 3% U in molasses fed ad libitum and the mix proved to be an effective substitute feed where paddocks were bare or bushfires had occurred. Mature cows, well adapted to molasses with 3% U and fed ad libitum, had daily voluntary intakes in excess of 2% of LW in drought situations, with average intakes ranging from 1.2 to 2%. Cows fed at this level with minimal roughage gained in body condition and often showed signs of oestrus For survival alone, the mix was too expensive in some situations, so restricted amounts were fed twice weekly. Depending on trough capacity and intake patterns, troughs could be empty 24 to 48 h after filling. Cattle then ate much more at the next feeding, however, weekly amounts of 20 to 30 kg were fed to cows. The 3% U ad libitum mix remains an option for producers, especially near bulk molasses terminals, because of the larger quantity of molasses to transport, where a greater level of substitute feeding may be necessary to ensure survival or in special circumstances to maintain high production levels during a drought.

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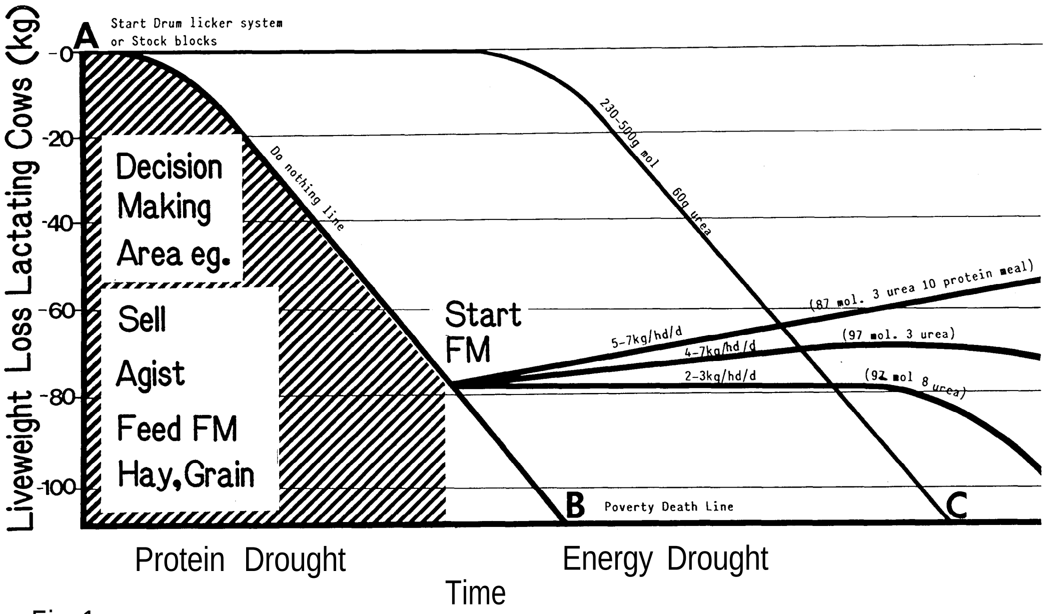


Fig 1

Drought management options for Queensland beef properties

<u>8% urea mix</u> The 3% U mix may not be suitable for producers on large properties or some distance from a molasses source, as they require an ad libitum system with lower intake levels. In the absence of a satisfactory repellant or inhibitory agent, higher concentrations of urea were used to reduce or regulate molasses intakes. This effect has been known for some time (Beames 1960; Silvestre et al. 1977).

Working with innovative producers in the Mackay district, Beasley found that a concentration of about 8% U gave satisfactory intakes. This mix has been fed ad libitum successfully on many central Queensland properties, with few deaths from urea toxicity being recorded and herds of more than 1 000 head being kept alive for up to six months. Variations of between 5 % and 10% U were used in specific cases to regulate intakes of molasses.

The 8% U level was initially an arbitrary one, though it resulted in the daily intakes of 1.5 to 4 kg/d for lactating cows. The availability of paddock roughage and behavioural aspects may modify intakes under grazing in a drought. A case was encountered in the Emerald district with intakes up to 6 kg/d of the 8% U mix for steers without deaths occurring (Barnett pers. comm.). Overall, for yearlings and growing cattle intakes ranged from 1 to 2 kg/d.

<u>Feeding pattern</u> Both the 3% and 8% U mixes were most successful when fed ad libitum and did cattle drastically change their foraging habits - they would have a lick and go. However, a drawback of the 3% U mix with intermittent (twice weekly) feeding is that cattle tend to remain near the troughs. The overall effect on intakes of different feeding patterns have only been ascertained in very large paddocks, where cattle do not graze the whole paddock, as well as under the intermittent feeding system. With the 8% U mix, higher intakes following periods

with empty troughs can lead to possible toxicity problems, particularly if mixing is not thorough (Beasley unpub. data). For these reasons, an ad libitum system is always recommended for the 8% U mix. An objective comparison between the 8% U mix fed ad libitum and the 3% U mix fed intermittently is needed to determine their appropriate roles in drought feeding programmes.

Incorporating a protein rich meal Research has demonstrated the beneficial effects of feeding a protein source which 'escapes rumen degradation (Leng et al. 1977). Cottonseed meal and MBM have been incorporated in molasses mixtures containing up to 3% U. The levels of protein meal (PM) have ranged from 2 to 13% (w/w) of molasses. A combination of urea/protected protein gives a better response than each nitrogen source alone (Lindsay and Loxton 1981). The mixes incorporating PM were rarely fed ad libitum because of the cost, but generally twice weekly to give lactating cows 30 to 40 kg of the mixture per week. Mixes incorporating high levels of PM were generally fed to improve the body condition of cattle.

Effectiveness All mixes were effective for survival in a wide range of environments. On sparse pastures, lactating cows were seen to cycle on all FM mixes. All mixes stopped poverty deaths once FM feeding commenced. After 4 to 5 mth of feeding the 8% U mix, there were some reports of poverty in cows where paddock roughage was scarce (see next paper). In most cases the 8% U mix fed ad libitum appeared to reduce LW losses and enabled cows to survive for 4 to 6 mth with practically no paddock feed. Estimates of non-consumers varied from zero in some areas to 3 to 5% in the spear grass zone and as high as 10% on better soil - types.

Problems We consider that thorough mixing of the ration is the most critical factor associated with successful FM feeding. As expected with a ration incorporating urea, some deaths from urea toxicity were reported. The major cause appeared to be inadequate mixing, since most cases occurred with hand-mixing. Very few deaths were reported whenever PM were included in the mixture. A second factor was rain falling on the mix, but deaths after rain were generally associated with hand mixed licks. Some deaths have been attributed to molasses toxicity with the 3% mix fed ad libitum in the Bundaberg and Rockhampton districts.

On-farm storage and distribution The least-cost and most popular on-farm storage was one or more concrete tanks (23 000 L) treated with a protective inner coating of bitumastic paint or epoxy resins. Molasses flows by gravity through outlets of 75 to 150 mm, but in some cases pumps have been installed to increase the transfer rate. Steel, fibreglass and treated galvanised tanks are also used on large properties, whereas 200 L drums were often used in the south and west of the state and on small properties.

Tank to paddock distribution is by low-cost, ground or power-take-off (PTO) driven mixers (see Pharoah and Barrow 1977) with capacities from 900 to 2 000 L. For PTO mixers the molasses, urea and/or PM are mixed for 20 to 30 min prior to paddock distribution. For ground-driven mixers, the tanker full of ingredients should be driven at least 8 km. Alternatively, the separate ingredients are transported to the feeding trough and mixed in situ using an auger + mixing paddle attachment to a chainsaw.

Conclusion The FM system was a most successful one for stock owners in Queensland in the 1979-83 drought. Its success was based on its cost relative to other substitute feeds, lower labour requirements than other fodders and good flexibility. We estimated that drought deaths due to poverty on properties which fed cattle, were substantially lower under the FM system than under the alternative systems used in previous droughts.

## FIELD EXPERIENCES WITH FORTIFIED MOLASSES

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During the 1979-83 drought many producers throughout Queensland used FM as a drought feed; particularly for their most vulnerable stock, breeding females, weaners and young calves. Feeding programmes varied according to resources on the property, dry matter availability and more importantly the body condition of animals. While the main drought feeds were molasses, grain (sorghum, barley, oats and wheat), hay and edible scrub, the usage of any one feed type is unknown. Some producers were prepared to pay as much as $300/t for hay. QDPI beef cattle officers were involved in many field observations with cattle and sheep fed FM. As this experience forms the basis of our knowledge of FM feeding programmes, it is appropriate to document our observations, using selected case studies, as well as to draw conclusions and make recommendations for future droughts.

In northern Queensland the 3% or 8% U mixes were fed on many properties while some used 3% U and 8% MBM. In central Queensland, the commonest mix was 8% U. Mechanical mixing was used widely towards the end of the drought and the frequency of feeding aimed to ensure FM was available at all times. In some instances urea concentrations were varied to achieve the desired intakes of molasses at different feeding points on a property. For example to obtain the same intakes of molasses on one northern coastal property, 3 to 5% U mixes were used in 1982, while 4% U was satisfactory in 1981, but 8% U was needed in 1979 (Tyler pers. comm.). In contrast in southern Queensland, the usual mix was 1.5% U with 13% CSM for weak cattle and 5% CSM for those in strong condition. It was hand mixed in situ and fed twice weekly. Initially CSM was used, simply because it was as cheap as urea, readily available and safer to feed. To our knowledge, 8% U mixes were not used in southern Queensland.

The following case studies illustrate a range of situations under which FM was fed, the problems encountered, solutions devised, responses of the cattle and feeding costs. We must stress that they were observations and should not be interpreted with the same vigour as strict experimental studies.

Northern Queensland (Smith 1983) On a property in the Mt Surprise area 2 000 breeding females and weaners were fed FM for 3 mth commencing in October 1982. There was very little feed available, the cattle were in poor condition and deaths were occurring, despite the earlier feeding of salt, urea and phosphorus licks. After an initial FM mixture of 12% U, mechanically mixed, was fed to a 'test' group of 50 cows, 10 died. Then a 3 d supply of a 2% U mix was fed and no more died. Despite the fear of urea toxicity, an 8% U mix was immediately fed and the occasional death during the next few weeks was attributed to a lack of trough space and failure to maintain a continuous supply of FM. The weaners were fed initially an 8% U mix with 8% MBM for 28 d, during which time mortalities ceased and body condition improved markedly, and then returned to the 8% U mix, without further deaths. The average intake for the herd was 2 kg FM/d, with FM being fed every 3 d to ensure ad libitum access.

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On a Charters Towers property, 3 000 mixed cattle, with access to limited roughage, were fed an FM mix of 3% U and 8% MBM for 5 mth. Some cattle had died of poverty before feeding started. Both hand and mechanical mixing were used without deaths from urea toxicity. With ad libitum feeding in open troughs, intakes averaged 2.5 kg/d. The outstanding factor emerging from this observation was the performance of lactating cows and their calves. The cows remained strong with an apparently good milk supply and their calves continued to grow and maintain forward store condition. The monthly cost of feeding 2 kg FM/d was $6.33/hd. Omitting the MBM would save c. 50c/hd, but is not justified in view of the improved performance of the cattle and the absence of urea toxicity.

Central Queensland (Dodt unpub. data) On a property in the Mackay district, an 8% U mix, mechanically mixed, was first fed to 184 weaners in July 1982. When no urea toxicity problems were encountered, the FM feeding programme was extended to the breeding herd and between mid August and early January, 1 100 cattle were fed. Standing pasture was sparse to absent. Intakes for the cows settled around 1.8 to 2.75 kg/d, depending on the pasture available in each paddock. Intakes for the weaners never exceeded 0.9 kg/d and decreased as the season progressed. By early November, the strength and condition of the weaners had deteriorated and instead 8% MBM in molasses was fed. By the fifth day intake reached 1.8 kg/d and so this level was fed twice weekly and the weaners improved rapidly. Similarly, some weak cows had to be segregated for special feeding treatment.

On another Mackay property, 11 cattle in a group of 120 died from urea toxicity when introduced to FM with 8% U that was mixed by hand. The urea was replaced with 1.5% MBM, but the cattle did not eat it. The MBM level was reduced then to only 0.3%, and on acceptance of this mix, MBM was gradually increased to 8% over 14 d. The mixture was fed ad libitum every 3 d for 4 wk until effective rains fell and intakes averaged 2.4 kg/d.

Field experiences throughout central Queensland demonstrated that the principal effect of increasing the concentration of urea in molasses was to reduce the intake of FM (Nicol pers. comm.). While urea concentrations varied from 2.5 to 10%, producers found the 8% U mix most satisfactory and gave stable intakes. The monthly cost of this mix, at 2 kg intake/d, was $2.60/hd.

A vealer producer whose calves achieve pre-weaning gains of 1.0 kg/d in normal seasons, fed 3% U and 10% CSM/MBM at 6 kg/cow/d. This enabled him to sell his vealers (270 kg LW) at $1.00/kg instead of 0.45c/kg LW, if he had been forced to sell earlier (200 kg LW). The costs of feeding the cows with FM were compared will those of conventional hay feeding on another property (Nicol and Wicksteed pers. comm.). The FM was 0.8c/MJ metabolizable energy and 65c/kg crude protein whereas hay was 3.4 c and $1.46/kg, respectively.

South western Queensland (Knight 1983) On a St George property 500 cows were fed FM with 1.5% U and 13% CSM, mixed by hand. Because the majority of cows were in late pregnancy and low body condition, acceptance of the mix had to be achieved quickly. FM was fed 3.0 kg/d twice weekly. The body condition of the cows improved rapidly and they were able to rear strong calves. All cattle accepted FM and a 'tail' of weak animals did not develop in the herd. There were no deaths due to molasses and/or urea toxicity. The monthly cost of this mixture was $10.27/hd. The 12 wk old calves (mean LW 95 kg) were strategically weaned, fed FM with 13% CSM ad libitum in yards and later also given a 200 ha paddock with some dry feed. After 16 wk, the calves averaged 116 kg LW having gained 0.18 kg/d. They ate 1.5 kg of the FM mix/d.

In this area the landed price of molasses was $48/t and for wheat was $115/t. To compete, the price of wheat needed to be $75.

Whenever feeding troughs were placed some distance from watering points, stock did not remain there and so restrict their grazing time. In contrast to research results (Gulbransen pers. comm.), we consider that some roughage should be present when feeding FM, because on one property a producer stopped cutting edible scrub and his cows developed scours and lost condition.

Fortified molasses for sheep (Powell and Knight unpub. data). It is of interest that FM with CSM was a very successful, low cost, survival feed for sheep in southern Queensland. Pregnant and lambing ewes were kept alive and produced high lambing percentages (c. 90%) when fed 450 to 650 g of molasses with 15% CSM/d. Dry sheep required 200 to 300 g of molasses with 10% CSM. Some producers partly replaced the CSM with urea, but urea toxicity problems resulted with as little as 1.5% U, probably due to inadequate mixing. Other producers claimed success with 5 to 6% U.

General observations and conclusions Feeding FM reduced deaths in large herds of cows, weaners and calves throughout Queensland. From recent field experience, FM offers producers a simple, lower cost system for survival drought feeding, requiring less labour and capital than do grain or hay. It also increases the policy options available to producers, since FM mixes enable them to trade out of a drought rather than being forced to sell cattle hastily.

More care and management expertise is required when feeding 3 or 8% U mixes than with those incorporating a PM, particularly as mortalities were mostly associated with hand mixing of the 3% and 8% U mixes. With the latter mix, it is essential that some FM is on offer at all times to attain stable daily feed intakes and to reduce the risk of deaths from urea toxicity. Another disadvantage with the 8% U mix is that a 'tail' develops in the herd after 3 to 4 mth. However, when segregated and also fed PM these animals usually improved.

Molasses fortified with urea and PM is suitable for all forms of drought feeding; few deaths due to poverty or toxicity were reported; it had a dramatic 'pick-me-up' effect on weak animals; it can be successfully fed to calves as young as 2 to 3 mth of age, cows supporting older calves and to sheep and cattle grazing the same paddock. Problems were encountered with molasses of a very low viscosity, as cattle tended to drink it, thus quickly consuming 3 d supply and also overeating at the next feeding. Palatability problems were encountered with MBM, though its gradual introduction into the molasses was satisfactory. There were no problems with CSM or sunflower meal.

The simplicity of FM feeding relative to the DL system aided its adoption. Its spread was based on media releases, producer-to-producer contact and occasional field days. At one office alone, an average of 40 enquiries were dealt with per week (Venamore pers. comm.) and so simple advice was essential.

In southern and northern Queensland some producers feeding c. 3 kg FM with MBM/d found that calves did not appear to be causing an undue demand on their dams (Knight, Round, Smith pers. comm.). Many producers had already weaned most of their calves. This raises the question of the need to wean early and the appropriate age range for weaning when feeding FM with PM, but FM can never substitute for good weaning management. With DL feeding of urea/molasses in earlier droughts or FM without MBM, lactating cows had difficulty coping with their calves and so for these systems, early weaning of calves older than 2 mth of age is still recommended to conserve the condition and strength of cows.

Whenever large numbers of cattle were fed FM, correspondingly large quantities had to be transported, stored, mixed and fed to livestock. For some producers these quantities were a problem, and with a declining rural labour force, highlighted the need for easy, bulk handling and mixing facilities.

More field research on the role and optimal amount of true protein to feed to different classes of cattle, especially cows at different stages of pregnancy and lactation, would benefit graziers in planning drought feeding programmes.

## SUPPLY, DISTRIBUTION AND STORAGE OF MOLASSES

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The sugar cane crushing season extends from June to early December. During this period in normal years, molasses is first stored in 2 000 to 3 000 t tanks at the mills. This storage capacity is normally adequate for local demand, but surplus molasses is constantly transferred to Australian Molasses Pool depots and usually exported. Exports are organized in advance to ensure that storage capacity at terminals is not overtaxed, as the entire season's production cannot be accommodated. Export commitments must be met, even if local demand increases during droughts. At the end of crushing, mills plan to fill their bulk tanks to provide for local demand although some molasses is available from the Molasses Pool.

The production and disposal of molasses over the last five years is given in Table 1, with 51% being used for fermentation, 25% for stockfeed and 24% for exports. The quantity fermented is relatively constant. Exports depend on local demand for stockfeed, but this is influenced markedly by droughts.

TABLE 1 Molasses production and disposal ('000 tonnes) (source - Aust. Molasses Pool)

| | 1978 | 1979 | 1980 | 1981 | 1982 | Mean |
|---|---|---|---|---|---|---|
| Production | | | | | | |
| Qld and N.S.W. | 577 | 598 | 713 | 719 | 726 | 667 |
| Disposals | | | | | | |
| Exports | 109 | 143 | 130 | 201 | 216 | 160 |
| Fermentation | 362 | 349 | 334 | 324 | 320 | 338 |
| Stockfeed | 120 | 141 | 197 | 161 | 226 | 169 |
| Other | 2 | 6 | 7 | 6 | 6 | 5 |
| Total | 594 | 639 | 667 | 692 | 767 | 672 |
| Stock at end of crushing | | | | | | |
| At mill | 67 | 37 | 51 | 59 | 30 | 49 |
| At terminal | 115 | 100 | 136 | 152 | 136 | 128 |
| Total | 181 | 140 | 186 | 211 | 166 | 177 |

Note - Season totals do not balance mainly due to stocks carried forward. Years are from 1 February to 31 January. N.S.W. accounts for 7% of total production.

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A large proportion of the stockfeed molasses is used for proprietary blocks, in feedlots and on dairy farms. From the records of non-drought years (for 1976 to 1978 and 1981), annual usage averages 125 000 t. On this basis, approximately 100 000 t of molasses was used for drought feeding in 1982.

If the average drought animal was fed 2.5 kg molasses/d, this 100 000 t could have fed 400 000 cattle for 100 d. Allowing for other routine needs, the maximum amount of molasses for drought feeding would only occur when none was exported. Thus in 1982, if the 316 000 t had been available, the potential number of stock fed could have trebled. In practice, this could not currently happen as there is insufficient storage capacity at mills, terminals and properties.

Normally, molasses stored at the end of crushing at mills and terminals is sufficient for fermentation and normal stockfeed needs. About 50% (c. 25 000 t) of mill storage and c. 40 000 t at the terminals is available for emergency stockfeed. Using this carryover, 260 000 cattle (or 6% of Queensland's breeding herd) could be fed for 100 d some time before the next crushing season. In a severe Queensland drought, some 600 000 cattle die, so this is a minimum target for survival feeding. To meet this need, on-farm storage must increase. If only 2 000 of the 21 000 beef properties in Queensland each stored 32 t molasses, the off-season drought feeding capacity would double. With this capacity over 0.5 m cattle could be fed - equivalent to numbers fed substantial amounts of molasses in the 1982-83 drought.

A major deterrent to the development of on-farm storage of molasses is the effect of Government drought assistance, encouraging producers to postpone purchases. With this assistance, molasses is cheaper to buy and transport in droughts.

<u>Storage and distribution for stockfeed</u> In normal years Queensland's on-farm storage is c. 30 000 t and concentrated on dairy fanns. The beef industry has not generally adopted on-farm storage. However, following the widespread adoption of FM feeding in the last drought and the increase in molasses usage, more storages will probably be built on beef properties.

Most molasses is transported by road in various sized tanks from mills to properties. A considerable amount is in 200 L drums, but this method is becoming less popular because of the slowness of filling at the mills, lack of facilities at large terminals, leaking drums and the difficulty in handling full (up to 330 kg) drums. The transport of molasses for drought feeding purposes by rail tankers is not realistic during the crushing season, as all tankers are usually needed to transport molasses from the mills to terminals. However, rail is used to take molasses inland, in 200 L drums or larger bulk tanks.

The major problem with molasses supplies during drought is at the southern most terminal, Bundaberg, Once more southerly mills run out, this terminal is the main source of supply for southern Queensland and other states. Usage from Bundaberg peaked at just over 2 000 t/wk in 1982 and shortages developed. Shipments by sea were organised by the Molasses Pool, usually of c. 10 000 t from Townsville and each costing c. $260 000, subsidised by the Commonwealth (56%) and by Queensland (18%) governments. Shipments are made at considerable risk, because this high priced molasses can become unsaleable overnight if the drought breaks.

In late 1982 the Commonwealth and State Governments approved a scheme to construct molasses storages at central locations in western Queensland. Ten storages of a total of 1 400 t capacity have been approved (August 1983), but only four have been built, with an average capacity of 189 t and capital cost of $47500. This storage is small relative to overall production. Other disadvantages relate to who will finance the purchase of molasses, manage the facility, and who pays for storage costs between droughts. The effect of high summer ambient temperatures on the molasses in these storages is unknown.

As a drought develops, the amount of molasses needed for stockfeed is continuously kept under review by the Molasses Pool and the QDPI Drought Secretariat but it is only possible to estimate very broadly the likely requirements in an area. Indications of the likely usage are obtained from beef cattle officers, collated and discussed with the Molasses Pool. The most useful guage is the weekly amounts taken for stockfeed purposes at mills and terminals.

Molasses storage problems The problems of storing molasses are reviewed fully by Daly (1983). Fresh molasses is cooled from 45° to 50°C to about 30°C before entering storage at the mills (Dunford 1976). During the next two months, it can show considerable gas formation and frothing, resulting in the production of carbon dioxide and heat. The chemical reactions are many, complex and not fully understood, but the most significant one is believed to be that of carbohydrates (usually reducing sugars) with amino acids or amides (White et al. 1983). The carbon dioxide bubbles can cause the molasses to expand up to 30% in volume and so overflow or burst its container. The gas generation rate depends on temperature, with the rate at 40°C three times that at 30°C (Honig 1975) and when the temperature rises, decomposition increases and an explosion can occur (Fromen and Bowland 1959; Agarwal et al. 1978). The reducing sugars producing carbon dioxide are eventually exhausted and gas formation stops. Until this occurs, the atmosphere inside a molasses tank is dangerous to man. In most instances, problems arise when highly viscous molasses is heated to facilitate handling.

Fresh molasses needs to be monitored for the degree of frothing and temperature changes. Above 40°C excessive frothing occurs. The specific gravity of fresh molasses, normally c. 1.4 kg/L, can also indicate tendency to froth (Trivett 1953). At sugar mills, temperature rises and frothing are controlled by compressed air, but excessive aeration can increase frothing. Compressed air can be used for on-farm storages (see Daly 1983), with 103 k Pa being most effective (Trivett 1953). It is inadvisable to add water to molasses in storage, as this causes fermention and spoilage.

For long term storage, Lampan (1979) recommends that the total sugar content of molasses should be above 43% (as-is basis) and the temperature below 28°C. However, the average total sugar content of 49.9% in Queensland molasses (Wythes et al. 1978) is above this critical level. Lampan (1979) also recommends that molasses should not be heated above 38°C as this reduces its nutritive value. Above 45°C, it is caramelized and charred.

Conclusion The quantity of molasses available from mills and the Molasses Pool for drought feeding is limited by storage capacity at depots and more importantly on-farm storages. If molasses is to be used more extensively as a drought feed, incentives should be given to encourage on-farm storage in non-drought years. When a drought does occur, considerable difficulty is experienced in determining likely requirements and arranging exports. During the first 2 mth of storage fresh molasses should be monitored to control the development of frothing.

## GENERAL CONCLUSIONS AND RECOMMENDATIONS

A.J. ERNST and J.R. WYTHES

We consider that molasses and urea with or without PM is a successful drought feed for beef cattle and sheep in Queensland. Limited pen studies suggest that FM should be a satisfactory drought feed for cattle. Field experiences during the past four years have borne this out. It is relatively cheap, flexible, and easily handled. The use of FM has greatly reduced deaths, particularly among cows, calves and weaners and allowed many producers to trade out of a drought situation rather than having to sell at an inopportune time.

This system is not fool proof and deaths from urea toxicity can occur. In practice there were few, were generally associated with the feeding of urea only mixes at the beginning of feeding and were mostly explained by inadequate mixing. This problem did not occur where PM was included initially.

Because molasses is deficient in nitrogen, it is necessary to feed 3 to 4% U to satisfy an animal's maintenance requirements (Winks 1984) but frequently, greater amounts were used to limit the intake of molasses to the desired levels. There is no ideal mixture to satisfy all situations. The choice of particular FM mixes, and appropriate urea and PM concentrations, varied from property to property and sometimes within a property. This depended on the class of cattle being fed, their strength and body condition and the available paddock feed. The most commonly used mix was 8% U but its use was generally restricted to northern and central Queensland. After 3 to 4 mth of feeding, PM was often included in the mix fed to the weakest animals and their condition usually improved markedly. In southern Queensland the trend was to use low urea concentration with some PM from the start of feeding, as all cattle generally performed satisfactorily. In all areas, the choice of which PM depended on its availability and cost.

The extensive adoption of FM feeding is likely to be limited by the availability of both on and off farm storage for molasses. However, problems exist in forecasting accurately the total requirements for molasses and distributing it to drought affected areas. One way of achieving greater elasticity of molasses supplies would be for producers to build more on-farm storage. The effects of high environmental temperatures on the storage life of molasses in the more extreme climatic areas of western Queensland are unknown. However; if water is excluded and temperature and sugar content are monitored, it is possible to predict what will happen.

In planning for future droughts, there are a number of questions to be answered. What will be the relative costs of the ingredients of FM and how cheap will they be relative to grain and hay? How many producers will use FM and so what will be the likely demand for molasses? How to improve the further distribution and ease of handling molasses from the mill to properties? We believe that the use of FM will increase, as producers realise its cheapness relative to other drought feeds and others begin FM feeding programmes. The fear of urea poisoning has been overcome largely by the use of mechanical mixers. In the next drought many producers may opt not to feed although pressures from non-rural activist groups may eliminate this option.

While the basic technology exists, further research is needed. This information includes: (i) an intake inhibitor other than high concentrations of urea, particularly if urea prices rise, (ii) optimum intakes of FM or optimum levels of ingredients to ensure the survival of various classes of cattle, particularly lactating and pregnant cows and weak animals under paddock conditions, (iii) The importance of roughage and what is the role of the PM, (iv) management options available for using various FM mixes, (v) desirable weaning policies with different FM mixtures. Unfortunately the motivation for this kind of research is often lacking between droughts and it is hard to simulate drought conditions.

From the available data and our field experiences, we believe it is appropriate to make certain recommendations. The primary aim of drought management is the survival of the breeding herd by low cost and simple methods. We contend that the feeding of cows should start during late pregnancy and for other classes of young cattle at the first sign of imninent deaths due to poverty. Where the FM contains no PM, it is important to wean all calves older than 2 to 3 mth of age. Producers should segregate the most vulnerable parts of their breeding herd for feeding rather than feed en masse. On present knowledge producers now have another option for feeding their stock in droughts. However, it is still difficult to predict which mix will be the *most suited to individual property requirements. The volume of on-farm storage needs to be increased and it is essential to up grade the system of handling molasses between the mill and the farm. Although an argument against improved on-farm storage is the cost of buying molasses in non drought times, producers would be unwise to plan on receiving government subsidies in any future drought.

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