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Evaluation of high molasses diets in commercial feedlot operations

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ABSTRACT

Molasses is a palatable energy-dense feedstuff. In northern Australia, molasses has traditionally been seen as an energy supplement and a medium for delivering protein supplements. The major objective of this project has been to develop high molasses diets that could be used to underpin intensive cattle finishing enterprises in northern Australia. Molasses would provide feedlot operators with a relatively inexpensive energy dense feedstuff available from local sugar mills. High molasses diets developed by CSIRO Livestock Industries, Rockhampton have resulted in liveweight gains in excess of 1.2 kg/d in animal house experimentation. The inclusion of molasses in a commercial feedlot diet has resulted in average daily gains (ADG) of 1.2 to 1.7 kg/d. Carcass characteristics, subjective and objective measures of meat quality have been measured and found to be similar for conventional grain-based and high molasses fed cattle.

This report documents the results obtained in both phases of the project “Evaluation of high molasses diets in commercial feedlot operations”.

The project successfully demonstrated that high molasses diets could be used in commercial feedlots.

EXECUTIVE SUMMARY

In northern Australia, molasses has traditionally been seen as a medium for the delivery of mineral, protein and non-protein nitrogen supplements and as an energy supplement to ensure the survival of stock during droughts. Although molasses is currently used at low levels (<10%) in grain-based feedlot rations, it is a palatable energy-dense feedstuff and, as an alternative to other energy-dense feeds, has the potential to form the basis of high-production diets for feedlots near sugar cane growing areas.

Specific aims of the project were to:

- Formulate cost-effective diets, based on molasses, and including other agricultural by-products and co-products that allow intensive finishing of beef cattle in northern Australia.
- Achieve liveweight gains in excess of 1 kg/d at acceptable feed conversion efficiencies.
- Add to existing knowledge on maximum inclusion rates of specific nutrients, notably combinations of soluble sugars, fats and oils, so that productive diets, based on molasses, can be formulated using different companion feedstuffs without the need for further research.
- Determine the growth rate, feed conversion efficiency, carcass characteristics and eating quality of cattle fed a high molasses diet (50% molasses on a dry matter basis) and a diet with molasses substituting for part of the grain (29% molasses on a dry matter basis) in a standard feedlot diet.
- Provide data so the economics (cost of gain) of molasses inclusion in feedlot diets can be calculated.

The first phase involved animal house experiments to determine growth rates and carcass characteristics of cattle fed various high molasses and molasses and grain diets. The inclusion of the results obtained from phase 1 in this report also finalises the project Expanded use of molasses for feeder cattle (NAP3.106). The molasses inclusion rates that achieved the best liveweight gains in phase 1 were in the range of 45 to 60% molasses (dry matter basis) of the total diet. Brahman cross-bred steers with an initial live weight of 300 kg gained 1.8 and 1.6 kg/d during the first 80 days of the feeding period for the 45% and 60% molasses diets, respectively. Over the 140-day feeding period the weight gains were 1.4 and 1.5 kg/d, respectively. The higher the molasses inclusion rate, the more efficiently feed dry matter was converted to liveweight gain. There was a tendency for P8 fat depth to decrease with increasing molasses inclusion rate. Molasses inclusion rate had no effect on meat eating quality assessed under the Meat Standards

Australia (MSA) system.

Varying the molasses to grain ratio by replacing molasses with grain sorghum in a 60% molasses diet (60:0, 40:20, 20:40, 5:55), and so increasing the energy density of the total diet did not result in significant improvements in daily liveweight gains. However, there was a tendency towards an increase in daily gains from 1.2 to 1.4 kg/d as the proportion of grain in the diet increased. P8 fat depth significantly increased from 6 to 11 mm as the sorghum content of the diet was changed from 60% molasses/0% grain sorghum (60:0) to 5% molasses/55% sorghum (5:55). Substituting sorghum grain for molasses had no significant effect on MSA eating quality.

The second phase of the project evaluated “best bet” diets under commercial conditions. Two experiments were conducted at a commercial feedlot in the Brisbane Valley, using *Bos indicus* x *B. taurus* heifers to evaluate high molasses feeding in terms of growth rate, carcass characteristics and meat quality. In the first experiment, animals with an initial live weight of 325 kg gained 2.1, 1.7 or 1.3 kg/d when fed a diet containing ≤1%, 29% or 50% molasses (dry matter basis), respectively, for 64 days. Animals retained by the feedlot for a further 21 days and fed the 29% or 50% molasses (dry matter basis) diet gained 1.3 and 1.2 kg/d, respectively over a total of 85-days. In the second experiment, animals with an initial live weight of 322 kg gained 1.7 kg/d when fed the control, grain based, diet for 54 days and 1.2 kg/d when fed either the medium or high molasses diet over a total of 85-days. Both feedlot experiments demonstrated a tendency for P8 fat depth to decrease with increasing molasses inclusion rate. Replacing feed barley or maize with 29% or 50% molasses (dry matter basis) had no effect on meat eating quality assessed under the MSA system, objective measures of tenderness or meat and subcutaneous fat colour.

This project was made possible by the generous support of Australian Country Choice.

MAIN RESEARCH REPORT

1. Background

The current challenge for the northern Australian beef industry is to expand into Asian markets. These markets demand live cattle within well-defined classes, and carcasses within tight specifications. Asian markets also demand a continuity of supply that cannot be guaranteed from extensive grazing, given erratic seasonality of rainfall and variable pasture growth rates common in northern Australia. For a reliable supply of cattle to these markets, a period of intensive finishing is often necessary. A 100 kg increase in live weight in 100 days from the end of the growing season, mid-year, would enable cattle to be sold into specified markets up to 200 days earlier than had they remained in an extensive grazing situation. One option to achieve this growth rate is to utilise high levels of molasses in the finishing diets. High molasses diets for intensive feeding of cattle were pioneered in Cuba in the late 1960s (Preston *et al*., 1967). Once the requirements for rumen degradable and rumen undegradable protein (Preston and Willis, 1974) and the need for adequate roughage intake (Lousada and Preston, 1973, Rowe *et al*., 1979) were determined, liveweight gains of up to 1 kg/d were considered achievable. Queensland sugar mills produce more than one million tonnes of molasses per annum. North Queensland and the Herbert/Burdekin areas produce approximately 52% of total Queensland production and both areas export up to 94% of their production at low prices due to lack of domestic demand and limited storage capacity (Bortolussi and Hunter, 2000). A large proportion of the exported molasses could be sold on the domestic market if there was an assured demand. Molasses (11 MJ/kg DM) is often a cheaper source of energy than other energy dense feedstuffs. At an average price of $90.00 per tonne, delivered on-farm, molasses would cost about 1.1 cents per MJ of metabolisable energy. More conventional energy dense feedstuffs (approx. 14 MJ/ kg DM) at $200.00 per tonne landed would be approximately 1.4 to 1.6 cents per MJ of metabolisable energy. Including a relatively inexpensive energy source, such as molasses, in a feedlot diet may provide an effective means of increasing profitability and reducing production costs of finishing beef cattle in northern Australia. The inclusion of the results obtained from phase 1 in this report also finalises the project Expanded use of molasses for feeder cattle (NAP3.106).

2. Project Objectives

On the basis of the progress achieved in the animal house experiments (Phase 1), the decision to conduct experiments in a commercial feedlot (Phase 2) was ratified. This report details the findings of the experiments conducted in phase one and two of the project with the following objectives;

- Formulate cost-effective diets, based on molasses, and including other agricultural by-products and co-products that allow intensive finishing of beef cattle in northern Australia.

- Achieve liveweight gains in excess of 1 kg/d at acceptable feed conversion efficiencies.
- Add to existing knowledge on maximum inclusion rates of specific nutrients, notably combinations of soluble sugars, fats and oils, so that productive diets, based on molasses, can be formulated using different companion feedstuffs without the need for further research.
- Determine the growth rate, feed conversion efficiency, carcass characteristics and eating quality of cattle fed a high molasses diet (50% molasses on a dry matter basis) and a diet with molasses substituting for part of the grain (29% molasses on a dry matter basis) in a standard feedlot diet.
- Provide data so the economics (cost of gain) of molasses inclusion in feedlot diets can be calculated.

3. Methodology

Phase 1. Animal House Experiments

Experiment 1-The effect of increasing the molasses content of the diet on productivity of steers.

Thirty-two high-grade Brahman steers of initial live weight (mean ± sem) 299±4.8 kg were housed in individual pens in a roofed animal house, treated to control gastrointestinal Helminths and were free of cattle ticks. The animals were divided into four groups of eight steers per group. Groups were allocated, at random, to one of the following diets: 30, 45, 60 and 72.5 % molasses [dry matter (DM) basis]. The components of the diets were molasses, whole cotton seed, cottonseed meal, urea, Fibremax® (alkali treated bagasse) and a custom formulated mineral mix (Table A.1). The mineral mix contained 167 mg/kg P, 1000 mg/kg Cu, 13.3 mg/kg Se, 6,670 mg/kg Zn, vitamins A, D and E at 1,200 IU, 100 IU and 1 g/kg, respectively and monensin at 1667 mg/kg.

All diets were formulated to contain approximately 140 g/kg DM crude protein (CP) to ensure CP was not limiting. The steers were fed the experimental diets *ad libitum* for 25 weeks; five weeks preliminary feeding and 20 weeks during which feed intakes and growth rates were measured. A lengthy period of intensive feeding was chosen to ascertain whether symptoms of molasses toxicity and laminitis became apparent over time.

Diets (Table A.1) were prepared in a paddle type feed mixer. Urea, in solution, was mixed with molasses in the approximate proportions of 5:95 to lower viscosity of the molasses. Dry ingredients were mixed before the molasses/urea mixture was added.

All steers were implanted with 20 mg oestradiol- 17ß (Compudose 100®,Elanco Animal Health, Australia) at the beginning of the growth experiment and again 11 weeks later. The old implant was removed before the new one was inserted. Steers were weighed once a week 24 hours after feeding. The amount of feed offered was such that residues were between 0.5 and 1.0 kg/d and weighed daily. Mean daily intakes (g DM/kg LW/d) were calculated weekly (7d).

At the conclusion of the experiment, steers were transported to a local abattoir and slaughtered after 24 h lairage. After chilling overnight, sides were quartered at the $12^{th}/13^{th}$ rib. Eye muscle area (EMA), ultimate pH and P8 fat depth at the surface point aligned with the crest of the third sacral vertebrae were measured 20 minutes after quartering. AusMEAT and USDA marbling scores were obtained visually. Approximately 15 cm of the *M. longissimus dorsi* (LD) from the left side of each carcass, caudal to where it was sectioned at the $12^{th}/13^{th}$ rib site, was trimmed of excess fat, weighed and stored at –20°C for subsequent taste panel evaluations.

Representative tissue samples from one steer were subjected to testing for chemical residues.

Experiments 2&3 Digestion and excretion of nitrogen and potassium.

Six high grade Brahman steers of initial live weight (mean ± sem) 344±4.8 kg were fed the same 45% molasses diet *ad libitum* that was used in Experiment 1 (Table A.1) for eight weeks before being transferred to metabolism crates for eight days. Quantitative measurements of feed intake, faecal output and urine output were made over the final seven days for calculation of organic matter and nitrogen digestibilities and potassium excretion. The steers were then fed the 60% molasses diet (Table A.1) for a further four weeks before being returned to metabolism crates for eight days, with collection over the final seven days.

Experiment 4- The effect of substituting dietary molasses with grain on the productivity of steers.

Forty high-grade Brahman steers of initial live weight (mean ± sem) 360±10.6 kg were housed in individual pens in a roofed animal house, treated to control gastrointestinal Helminths and were free of cattle ticks. The animals were divided into five groups of eight steers per group. Groups were allocated, at random, to one of the following diets: 60% molasses (DM basis) (two groups), 40% molasses/20% cracked grain sorghum, 20% molasses/40% grain, 5% molasses/ 55% grain. The diets were formulated to contain approximately 130 g/kg DM CP (Table A.2). Steers were fed the experimental diets *ad libitum* for 15 weeks, three weeks preliminary feeding and 12 weeks during which feed intake and growth rate were measured. One of the 60 % molasses groups was fed good quality oaten hay *ad libitum* for the final two weeks of the 12-week period. The purpose of this treatment was to determine whether the higher than optimal pHs that were observed from high molasses diets in the first experiment could be reduced by withdrawing molasses from the diet in the final weeks before slaughter.

At the completion of the preliminary feeding period, all steers were implanted with 20 mg oestradiol-17ß at the commencement of the measurement period. Steers were weighed once a week before feeding and feed residues weighed daily.

At the conclusion of the experiment steers were transported to a local abattoir. Measurements and samples were collected as described for experiment 1.

Assessment of meat quality for consumers

Untrained consumer panels determined eating quality using a 0-100 scale for tenderness, juiciness, flavour and overall acceptability, with a score of 0 being least acceptable and a score of 100 being most acceptable. Individual scores were also combined, using weightings of 0.4, 0.1, 0.2 and 0.3 for tenderness, juiciness, flavour and overall acceptability respectively, into a combined meat quality score (CMQ4) (Polkinghorne *et al.,* 1999). Details of design, cooking procedures, conditions of tasting and number of panellists are given by Perry *et al*., (2001).

Chemical analysis

Dry matter was determined after oven drying at 100 ^{0}C to constant weight. Organic matter was determined after incineration at 550 ^{0}C for three hours. After Kjeldahl digestion, nitrogen concentration was determined by a modified method of Williams and Twine (1967) and absorbance measured using a spectrophotometer. Potassium concentration was determined by inductively coupled plasma spectroscopy following a nitric acid digest (Halvin and Soltanpour, 1980).

Statistical analysis

Data were analysed by analysis of variance (Statistical Analysis Systems Inc NC USA, 1992). Final live weight, live weight gain and carcass weight were analysed with live weight at the beginning of the period in which growth rate was measured as a covariate. Dressing percentage, eye muscle area, P8 fat depth and ultimate pH were analysed using carcass weight as a covariate. Means were considered to be significantly different at $P < 0.05$.

Phase 2. Experiments in a Commercial feedlot

Experiment 1- The effect of high molasses diets on animal productivity, carcass characteristics and eating quality of feedlot cattle.

The first experimental period commenced in December 2002 with the induction of 270 *Bos taurus* x *B. indicus* heifers of initial live weight (mean ± sem) 325±2.3 kg. At induction, all animals were weighed, vaccinated against clostridial infection (Ultravac 5in1® CSL Ltd.), treated for internal/external parasites (Cydectin® Fort Dodge Aust. Pty Ltd), implanted with trenbolone acetate and oestradiol benzoate (Synovex ® Fort Dodge Aust. Pty Ltd) and randomly allocated to one of three treatment groups, with 90 animals in each treatment group

Following induction, all animals were adapted to a conventional high grain feedlot diet (Table A.3) over a 12-day period. During the first six days of adaptation, all animals were fed a starter diet consisting of feed barley, hay, silage and molasses (43%, 20%, 10% and 12% as fed, respectively). An intermediate ration consisting of feed barley, bakery waste, silage and molasses (30%, 25%, 10% and 10% as fed, respectively) was then fed for the remaining six days of the adaptation period. There was no allowance made for the subsequent feeding of the medium (29% on DM basis) or high (50% on DM basis) molasses diets. Animal growth was measured over 64 days for the control group and 85 days for the medium and high molasses fed groups.

Experiment 2- The effect of high molasses diets on animal productivity and carcass characteristics of feedlot cattle.

The second experiment commenced in April 2004 with the induction of 234 *Bos taurus* x *B. indicus* heifers of initial live weight (mean ± sem) 322±1.5 kg. All animals were weighed, vaccinated against clostridial infection (Ultravac 5in1® CSL Ltd.), treated for internal/external parasites (Cydectin® Fort Dodge Aust. Pty Ltd) and implanted with trenbolone acetate and oestradiol (revalor-H ® Intervet Rural Co. Pty Ltd). At induction animals were randomly allocated to one of three treatment groups, with 78 animals in each treatment group.

Following induction, all animals were adapted to the control, medium molasses and high molasses diets (Table A.4) over 10 to 17 days commencing with a starter diet (45% grain, 26% roughage) for eight days for all animals.

Animals allocated to the control group (high grain diet) were then fed the intermediate diet only (39% grain, 15% bakery waste) for five days, offered a lucerne hay/control diet mix for one day and then fed the control diet (42% grain, 27% bakery waste).

Animals allocated to the medium molasses diet (29% molasses) were offered a hay/medium molasses diet mix on day nine before being fed the experimental diet from day 10.

Animals allocated to the high molasses diet (50% molasses) were fed a hay/medium molasses diet mix on day nine, fed the medium molasses diet from day 10 to 14, fed a hay/medium molasses diet mix for a further two days and then fed the high molasses diet from day 17.

Animal growth was measured over 42 days for the control group and 85 days for the molasses treatment groups.

Diets (Phase 2 experiments 1&2)

Cattle in both experiments were fed one of three diets varying in molasses content; ≤1, 29 or 50% on a DM basis (Table A.3, A.4). In experiment 1 control animals were offered a feedlot diet containing barley and bakery waste, and in experiment 2 maize and bakery waste as the main energy dense ingredients. The medium molasses diet contained 29% molasses and 38% grain on a DM basis, with the grain component either barley or maize in experiment 1 or 2, respectively, as main energy dense ingredients. The high molasses diet contained 50% molasses as the main energy dense ingredient and 18% or 23% whole cottonseed meal on a DM basis in experiment 1 or 2, respectively. All diets were prepared on site and offered, at a rate to ensure minimum wastage, once a day in concrete bunkers, to each group.

Slaughter and processing

For both experiments animals were transported by road, approximately 70km, to a commercial abattoir, held for 14-16h lairage and slaughtered using commercial best practice (Table A.5).

In the first experiment, 88 control animals and 45 animals from each molasses treatment group were slaughtered on the basis of subjective assessment. The live weight of these cattle was between 360 and 440kg on day 64. Animals that did not achieve these weights were retained and slaughtered after a total of 85 days in the feedlot. Any animals weighing less than 400 kg at the final weighing were retained by the feedlot.

In the second experiment, 50 control animals were slaughtered on the basis of the weight measured on day 42 and when their live weights were 400 kg or more on day 54. Twenty-eight control animals were retained by the feedlot and reallocated to non–experimental groups. Sixty-one and 60 animals from the medium and high molasses groups, respectively, were slaughtered when their live weights were 400 kg or more on day 85. Seventeen and 18 animals from the medium and high molasses groups, respectively, were retained by the feedlot and reallocated to non–experimental groups.

Twelve and 10 animals from the medium and high molasses groups, respectively, were not correctly identified at the abattoir and carcass data from these animals were not used.

Measurements

During the adaptation and treatment periods, feed offered was recorded daily for each group and used to derive average individual intakes throughout the experiment. Live weight was measured at induction, on day 42 and prior to slaughter. Individual daily liveweight gains (LWG) were calculated using linear regression.

Carcass characteristics (hot carcass weight, P8 fat depth, EMA, meat colour and subcutaneous and intra muscular fat colour) were measured in both experiments. After chilling, sides were quartered at the $12^{th}/13^{th}$ rib. Eye muscle area and P8 fat depth were measured after quartering. AusMEAT and USDA marbling scores were obtained visually.

Carcass pH and temperature decline were measured over a 10-hour period; post slaughter for 18, 20 and 19 carcasses randomly selected from the control, medium and high molasses treatments, respectively, in the first experiment only.

Meat quality

In the first experiment, single whole LD were boned-out 24h after slaughter, trimmed of excess fat and separated into cranial and caudal portions. Individual portions were vacuum packed and chilled to –0.5 °C over 5 hours. Caudal and cranial portions were transported chilled directly to Meat Standards Australia (MSA Armidale, NSW) or Food Science Australia (FSA Cannon Hill, Qld), respectively. All samples were aged for seven days and stored frozen at –20 °C prior to the determination of subjective meat quality by MSA and objective determination of meat quality by FSA. In the second slaughter event of the first experiment animals were processed in their separate treatment groups and carcass characteristics recorded.

Cranial portions of individual LD from the first experimental groups were used for objective analysis of meat quality after being cooked in a water bath for 60 minutes at 70 °C. Analysis included Warner-Bratzler shear force (initial yield and peak force), minolta colour (L*, a*, b*), compression, cooking loss, moisture and intramuscular fat content (Harris and Shorthose, 1991)

Caudal portions were collected for subjective determination of flavour, tenderness and juiciness to derive meat quality scores (MQ4) for each treatment group (Polkinghorne, *et al*., 1999).

LD was not removed from carcasses processed in the second experiment.

Statistical analyses

Data were analysed by analysis of variance, using generalised linear model procedure, SAS software (Statistical Analysis System, Inc., NC USA) to obtain means and standard error of the mean (sem). Only carcass traits from contemporary slaughter groups were analysed statistically. Duncan multiple range tests were performed to determine significant differences between means for treatment groups. Data were adjusted using initial live weight or carcass weight as a covariate where appropriate for animal productivity or carcass characteristics, respectively. Means were considered to be significantly different at $P<0.05$.

4. Results and Discussion

Phase 1. Animal house experiments

Experiment 1- The effect of increasing the molasses content of the diet on productivity of steers.

All animals remained in good health for the duration of the experiment. There were no clinical symptoms of molasses toxicity or laminitis. Feed intakes for all treatment groups were relatively constant from day to day, which implied there were no digestive problems such as sub-clinical acidosis that manifests itself in large fluctuations in daily intake. Figure 1 shows the live weight change over the entire preliminary and experimental feeding periods. Steers fed the 30% and

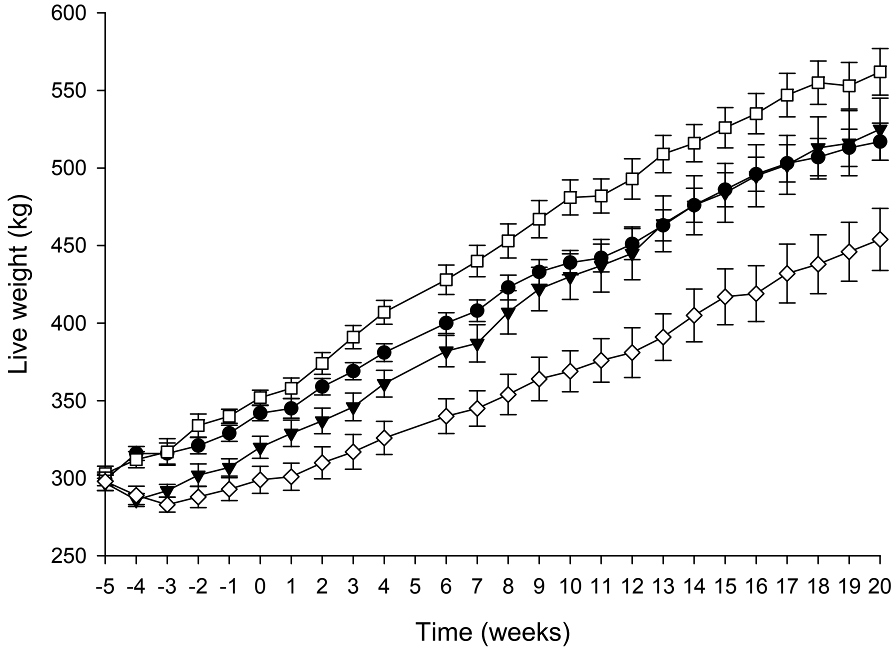

Figure 1: Phase 1 experiment 1. The effect of increasing the molasses content of the diet on animal productivity (● 30% molasses, □ 45% molasses, ▼60% molasses, ◊ 72.5% molasses). Vertical bars indicate standard error of the mean.

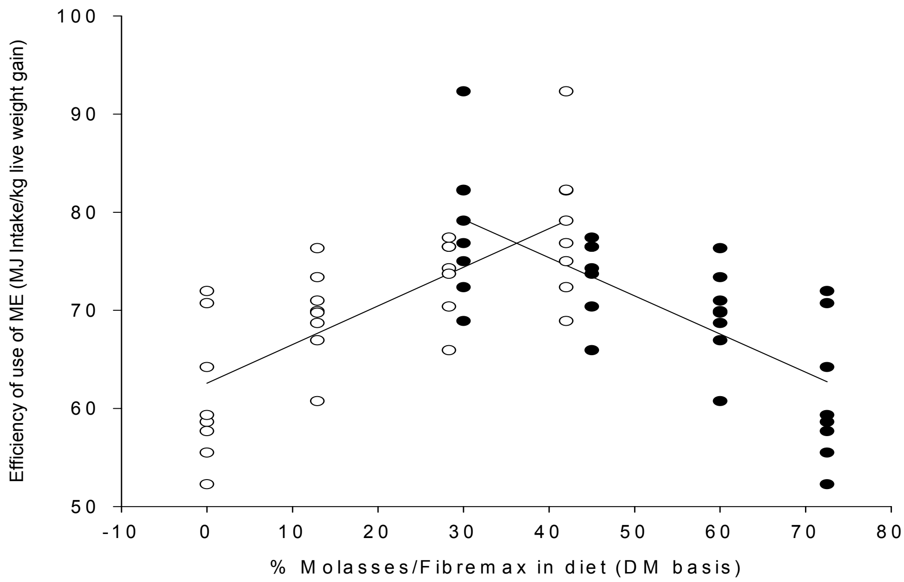

Figure 2: Phase 1 experiment 1. The relationship between molasses or roughage (alkali treated bagasse) content of the diet and calculated efficiency of use of metabolisable energy (ME) for growth (o molasses, ● Fibremax). The calculations of ME rely on the assumption that there was no interaction between dietary components on their expressed ME content.

45% molasses diets expressed *ad libitum* intakes from the commencement of the experiment whereas the steers fed the 60% and 72.5% molasses diets took three and six weeks, respectively, to achieve maximum intakes. This is reflected in the live weight gains of the steers during the first weeks of the feeding period (Figure 1). Intakes, on a g DM/kg LW basis, of the three lowest molasses inclusion groups declined during the second half of the 24-week feeding period. The intake of the 45% molasses group was 31-34 g DM/kg LW/d for the first 10 weeks declining to17-19 g DM/kg LW/d in final four weeks. In contrast, intakes of the steers fed the 72.5% molasses diet varied between 15 and 18 g DM/kg LW/d during weeks 7-25.

The feed intakes, live weight gains and feed conversion efficiencies during the period in which growth rate was measured are given in Table 1. Over the course of the experiment, intakes of steers fed the 72.5% molasses diet were significantly (P<0.001) lower than intakes in the other three treatment groups. During the first 80 days of the growth experiment there were significant differences in growth rate between treatment groups. The growth rate of steers fed 45% molasses was 1.8 kg/d compared to 1.1 kg/d for those fed 72.5% molasses (P<0.05). There were significant (P<0.01) differences in feed conversion efficiencies; the higher the molasses inclusion rate, the more efficiently feed DM was converted to body tissue (Table 1). There was a positive linear relationship (r^2=0.55, P<0.001) between the calculated efficiency of use of metabolisable energy (ME) for growth and the molasses content of the diet (Figure 2). The ME in the 72.5% molasses diet was used 21% more efficiently than the ME in the 30% molasses diet. Conversely there was a negative relationship (r^2=0.55, P<0.001) between the efficiency of use of ME for growth and the Fibremax® (alkali treated bagasse) content of the diets (Figure 2). Steers fed the 45% and 60 % molasses diets tended (P = 0.06) to have heavier carcasses.

No chemical residues were found in the carcass sampled. There was no dark cutting. Meat colour was towards the lighter end of the AusMeat colour range. Fat colour was white which might be expected from low carotene diets. Ultimate pHs were in the range 5.6-5.8 which is towards the higher end or higher than the range of 5.4-5.7 which is considered optimal. Assessment by untrained taste panels indicated eating quality was satisfactory. Treatment differences in all the eating quality evaluations were not significant (Table 1).

Experiment 2&3: Digestion and excretion of nitrogen and potassium.

The purpose of these experiments was to determine the route by which excess potassium was excreted from the body of cattle fed high molasses diets. Molasses is a rich source of potassium. It can be seen from Table 2 that steers fed the 45% and 60 % molasses diets had potassium intakes of 121-179 g/d, respectively. This contrasts with a requirement of 20-30 g/d (ARC 1980). The data indicated that potassium excretion exceeded intake. This is unlikely to be a reflection of the situation over a longer period than the seven days during which measurements were made for this experiment. The results do demonstrate that the major route of excretion was in urine. The digestibilities of organic matter and nitrogen in the two diets are given in Table 2.

Experiment 4: The effect of substituting dietary molasses with grain on the productivity of steers.

In this experiment, the high grain content in some diets necessitated a 21-day adaptation period prior to the 84-day period of measurement of feed intake and live weight gain. Treatment group intakes (g DM/kg LW/d) of the molasses grain mixtures week by week were constant. Intake of the long-chopped cereal hay during the two weeks immediately prior to slaughter by one of the groups previously fed 60% molasses was low, averaging just over 1% of live weight (Table 3). Intakes of the diets containing sorghum grain were significantly higher ($P<0.001$) than the diets of 60% molasses with no grain. There were no significant differences in the rate of liveweight gain between treatment groups, nor were there significant differences in feed conversion efficiency (Table 3). With inclusion of sorghum grain in the diets, the linear relationship between molasses inclusion rate or sorghum inclusion rate and the efficiency of use of ME for growth was not significant ($r^2=0.04$, $P=0.14$). The relationship between the roughage (alkali treated bagasse) content of the diet and the efficiency of use of ME for growth was also not significant ($r^2=0.04$, $P=0.14$).

There was a significant ($P<0.01$) positive relationship between increasing inclusion rate of grain in the diet and carcass weight. Similarly, subcutaneous fat depth at the P8 site significantly ($P<0.05$) increased with increased inclusion rate of grain. Intramuscular fat deposition, assessed visually, was very low in all animals. Treatment differences in AusMeat marbling score and USDA marbling score were not significant. Inclusion rate of grain had no significant effect on ultimate pH of the LD. Feeding cereal hay rather than molasses for the final two weeks before slaughter also had no significant effect on pH.

Varying the proportions of molasses and grain in the diet had no significant affect on objective or subjective measures of tenderness (Table 3). There was also no significant treatment effect on the eating quality of beef assessed by untrained taste panels.

Table 1. Phase 1, experiment 1. Feed intake, growth rate, carcass characteristics and meat eating quality of steers fed molasses based diets (data analysed with initial weight[1] or carcass weight[2] as a covariate).

	Experimental diet						
Molasses content (%)	**30**	**45**	**60**	**72.5**	**sem**	**Signif of treatment**	**Signif of covariate**
Mean intakes (g DM/kg LW/d)							
day 1-80[1]	26.4[a]	27.2[a]	24.7[a]	16.5[b]	0.59	*P*<0.001	ns
day 80-140[1]	21.5[a]	20.0[a]	20.6[a]	15.6[b]	0.40	*P*<0.001	ns
day 1-140[1]	24.2[a]	23.9[a]	22.9[a]	16.1[b]	0.93	*P*< 0.001	ns
Liveweight gains (kg/d)							
day 1-80[1]	1.3[ac]	1.8[b]	1.6[ab]	1.1[c]	0.13	*P*<0.05	ns
day 80-140[1]	1.2	1.2	1.4	1.3	0.11	ns	ns
day 1-140[1]	1.2	1.4	1.5	1.2	0.10	ns	ns
Feed conversion efficiencies (kg DMI/kg LWG)							
day 1-80[1]	8.1[a]	6.5[b]	6.5[b]	6.7[b]	0.38	*P*<0.01	ns
day 80-140[1]	8.6[a]	8.2[ab]	7.2[b]	5.5[c]	0.32	*P*<0.001	ns
day 1-140[1]	8.3[a]	7.2[b]	6.5[b]	5.5[c]	0.23	*P*>0.001	ns
Final liveweight[1] (kg)	494	523	537	498	14.6	ns	ns
Carcass wt.[1] (kg)	261	282	287	256	4.5	ns	*P*<0.01
Dressing %[2]	53	53	53	52	0.5	ns	ns
P8 fat depth[2] (mm)	15	15	12	11	1.8	ns	ns
Eye muscle area[2] (cm^2)	68	72	71	63	2.6	ns	*P*<0.01
Ultimate pH[2]	5.68	5.76	5.68	5.63	0.02	*P*<0.05	*P*<0.05
Ossification[2]	165	167	167	161	4.9	ns	ns
Tenderness[2]	46	61	51	51	5.6	ns	ns
Juiciness[2]	50	58	53	54	4.0	ns	ns
Flavour[2]	51	55	54	50	4.3	ns	ns
Overall acceptance[2]	50	58	53	47	4.8	ns	ns
CMQ4 score[2]	49	59	52	49	4.6	ns	ns

Means with different superscripts are significantly different (P<0.05). DM dry matter, DMI DM intake, LWG live weight gain.

Table 2: Phase 1 experiments 2&3. Intake and digestibility of organic matter and nitrogen, nitrogen retention, potassium intake and excretion of cattle fed diets containing 60% or 45% molasses (DM basis) (mean ± sem).

	60% molasses	45% molasses
Organic matter intake (kg/d)	7.6 ± 0.49	6.9 ± 0.24
Organic matter digestibility	0.7 ± 0.01	0.6 ± 0.02
Nitrogen intake (g/d)	201 ± 12.1	191.0 ± 8.1
Nitrogen digestibility	0.6 ± 0.01	0.6 ± 0.07
Nitrogen retention (g/d)	72.0 ± 7.2	61.0 ± 7.1
Potassium intake (g/d)	179.0 ± 12.4	121.0± 4.0
Potassium in urine (g/d)	208.0 ± 18.3	116.0 ± 11.6
Potassium in faeces (g/d)	8.0 ± 0.86	11.0 ± 1.0

Table 3. Phase 1, experiment 4. Feed intake, growth rate, carcass characteristics and meat eating quality of steers fed diets of differing proportions of molasses and sorghum grain. (Data analysed with initial weight[1] or carcass weight[2] as a covariate).

	Experimental diet (molasses : grain as percentage)							
	60 : 0 (hay)	**60 : 0**	**40 : 20**	**20 : 40**	**5 : 55**	**sem**	**Signif of treatment**	**Signif of covariate**
Feed intake[1] (gDM/kgLW/d)	19.8[a] (11.7)	19.2[a]	22.7[b]	24.5[b]	23.8[b]	0.97	*P*<0.001	ns
Liveweight gain[1] (kg/d)	1.3	1.2	1.4	1.4	1.4	0.12	ns	ns
Final weight[1] (kg)	483	483	489	504	495	9.4	ns	*P*<0.001
Feed conversion efficiency[1] (kg DMI/kg LWG)	6.7	6.7	8.0	7.4	7.6	0.39	ns	ns
Carcass weight[1] (kg)	245[a]	255[ab]	266[bc]	276[c]	269[bc]	5.2	*P*<0.01	*P*<0.001
Dressing[2] %	52[a]	54[b]	55[b]	56[b]	55[b]	0.68	*P*<0.01	ns
P8 fat depth[2] (mm)	6[a]	6[a]	8[ab]	10[b]	11[b]	1.1	*P*<0.05	ns
Eye muscle area[2] (cm^2)	67	74	71	70	72	2.2	ns	ns
Ultimate pH[2]	5.5	5.5	5.5	5.5	5.5	0.02	ns	ns
Peak force (kg)	4.8	5.3	5.7	5.8	5.6	0.33	ns	*P*<0.001
Initial yield (kg)	4.3	4.6	4.9	5.1	4.8	0.36	ns	*P*<0.01
PFIY (kg)	0.5	0.7	0.8	0.7	0.8	0.09	ns	ns
Compression (kg)	2.1	2.2	2.3	2.0	2.2	0.06	ns	ns
Tenderness[2]	49	40	46	44	36	4.3	ns	ns
Juiciness[2]	47	42	47	41	41	3.3	ns	ns
Flavour[2]	46	44	49	49	43	3.7	ns	ns
Overall acceptance[2]	45	41	49	46	39	3.7	ns	ns
CMQ4 score[2]	47	42	47	45	40	3.6	ns	ns

Means with different superscripts are significantly different (*P*<0.05). DM dry matter, DMI DM intake, LW live weight, PFIY peak force minus initial yield.

Phase 2- Commercial feedlot experiments

Average daily intakes on one pen per treatment basis were not significantly different (*P*>0.05) between diets for either of the two experimental periods (Tables 4 & 5). Feedlot staff reported that the high molasses diet remained acceptable to animals after rain.

Live weight gains

The average weight of animals at induction was 325 kg for experiment 1 and 322 kg for experiment 2. The pattern of liveweight gain to slaughter, including the adaptation periods, is shown in Figures 3 and 4 for experiments 1 and 2, respectively. Linear regression analysis indicated mean (±sem) daily gains of 2.1±0.04, 1.7±0.05 and 1.3±0.06kg during experiment 1 and 1.8±0.06, 1.2±0.04 and 1.2±0.03 during experiment 2 for the control, medium and high molasses fed animals, respectively. Daily gains were significantly different (*P*<0.05) between treatment groups for experiment 1, but similar for molasses fed animals during experiment 2. Average daily gains were not different for the medium and high molasses-fed animals that were carried over to 85 days in either experimental period (Table 4 & 5). The final weight achieved by the high molasses fed animals was significantly (*P*<0.05) less than that achieved by the control animals in experiment 1. In both experiments, molasses fed animals retained by the feedlot for up to 85 days were slaughtered when their mean (±sem) live weights were 428±5.1 kg in experiment 1 and 419±2.4 kg in experiment 2.

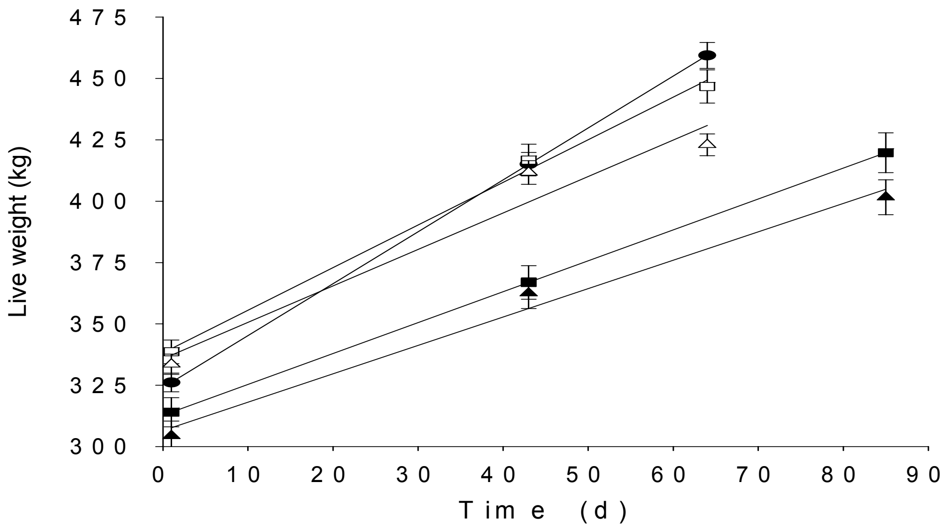

Figure 3: Phase 2 experiment 1. Mean (±sem) live weight from induction to day 85. The figure shows lines of best fit determined by linear regression. ● control (LWG, 2.1kg/d); □ medium molasses to day 64 (LWG, 1.7kg/d); ■ medium molasses to day 85 (LWG, 1.3kg/d); ∆ high molasses to day 64 (LWG, 1.3kg/d) ▲ high molasses diet to day 85 (LWG, 1.2kg/d).

Table 4. Phase 2 experiment 1. Feed intake, growth rate, carcass characteristics and meat quality of Brahman crossbred heifers fed molasses based diets (Least squares means±sem. Data analysed with initial[1] or carcass[2] weight as covariate)[A].

	Animals fed for 64 days			Animals fed for 85 days	
	Control	Medium molasses	High molasses	Medium molasses	High molasses
n	*88*	*45*	*45*	*36*	*32*
Initial weight (kg)	326 ± 4	337 ± 4	333 ± 4	322 ± 5.9	310 ± 6.8
Daily gain (kg/d) [1]	2.1 ± 0.04[a]	1.7 ± 0.05[b]	1.3 ± 0.06[c]	1.3±0.07	1.2±0.06
DM intake (g/kg LW/d)[B]	23	23	24	26	28
Feed conversion efficiency (kg DMI/ kg LWG)*	4.5	5.6	7.3	-	-
Final weight (kg)[1]	464 ± 3[a]	438 ± 4[b]	417 ± 4[c]	433 ± 5	421 ± 6
n	*18*	*20*	*19*	*36*	*32*
Carcass weight[1] (kg)	241 ± 1.6[a]	227 ± 2.4[b]	215 ± 2.3[c]	226 ± 3.2	213 ± 3.5
Dressing[2] %	52 ± 0.2	52 ± 0.3	52 ± 0.3	52 ± 0.4[a]	51 ± 0.4[b]
P8 fat depth (mm)	6.9 ± 0.5[a]	5.8 ± 0.5[a]	4.2 ± 0.5[b]	4.7 ± 0.3	5.3 ± 0.4
Eye muscle area (cm^2)	65 ± 1.7[a]	67 ± 1.5[ab]	72 ± 1.6[b]	65.1 ± 0.9	66.3 ± 1.0
Fat colour (subcutaneous)[D]	2.3 ± 0.2	2.6 ± 0.1	2.6 ± 0.2	2.1 ± 0.1	2.4 ± 0.2
Meat colour[C] L	40.9 ± 0.5	40.8 ± 0.5	40.3 ± 0.5		
a	22.4 ± 0.4	22.8 ± 0.4	22.3 ± 0.4		
b	10.2 ± 0.2	10.4 ± 0.2	10.1 ± 0.2		
Peak force (kg)	4.6 ± 0.1	4.5 ± 0.1	4.4 ± 0.1		
Initial yield (kg)	3.6 ± 0.1	3.3 ± 0.1	3.4 ± 0.1		
PFIY (kg)	1.0 ± 0.1	1.2 ± 0.1	1.0 ± 0.1		
Compression (kg)	1.8 ± 0.1	1.9 ± 0.1	1.9 ± 0.1		
Moisture (%)	76 ± 0.2[a]	76 ± 0.1[a]	77 ± 0.1[b]		
Intramuscular Fat (%)	1.5 ± 0.1[a]	1.4 ± 0.1[a]	0.8 ± 0.1[b]		
Tenderness[E]	44 ± 3.0	45 ± 2.8	47 ± 2.9		
Juiciness[E]	48 ± 2.7	54 ± 2.6	49 ± 2.6		
Flavour[E]	50 ± 2.6	54 ± 2.5	47 ± 2.6		
MQ4 score[E]	46 ±2.6	49 ± 2.5	47 ± 2.5		

[A]Dec-Feb, including adaptation period; [B]Intake of experimental diets fed from days 13-64 for control and molasses fed animals, days 13-85 for retained molasses fed animals per pen basis. *calculated on a per pen basis. PFIY peak force minus initial yield, [D] USDA fat colour standards, [C] Minolta colour system, [E] MSA clipped data. Means in the same row with different superscripts are significantly different (*P*<0.05).

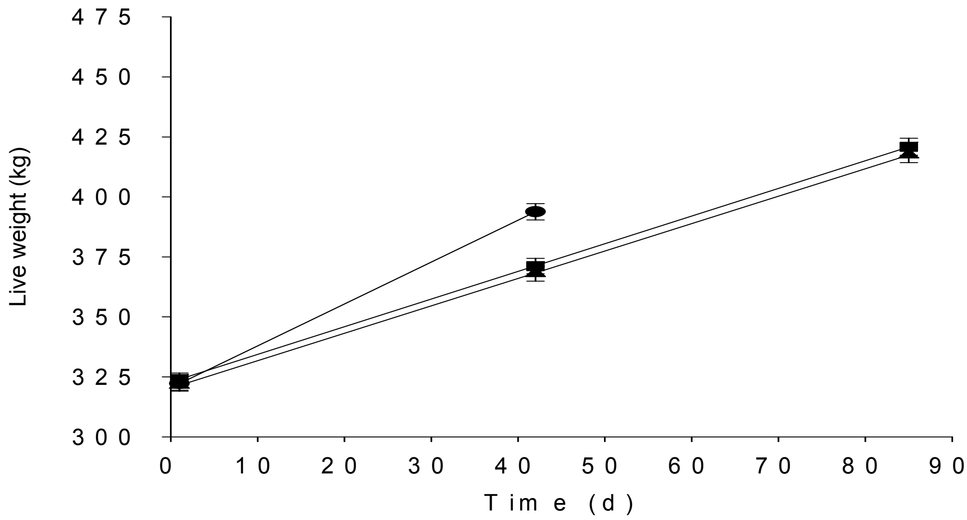

Figure 4: Phase 2 experiment 2. Mean (±sem) live weight from induction to day 85. The figure shows lines of best fit determined by linear regression for the medium and high molasses fed animals. ● control (LWG, 1.7kg/d); ■ medium molasses (LWG, 1.1kg/d); ▲ high molasses diet (LWG, 1.1kg/d). Vertical bars indicate standard error of the mean.

Table 5. Phase 2 experiment 2. Feed intake, growth rate and carcass characteristics of Brahman crossbred heifers fed molasses based diets (Least squares means±sem. Data analysed with initial[1] or carcass[2] weight as covariate)[A].

	Animals fed for 54 days	Animals fed for 85 days	
	Control	Medium molasses	High molasses
n	*78*	*78*	*78*
Initial weight (kg)	322 ± 2.7	324 ± 2.5	321 ± 2.5
Daily gain(kg/d) [D]	1.8 ± 0.06	1.2 ± 0.04	1.2 ± 0.03
DM intake (g/kg LW/d)[B]	23	24	24
Feed conversion efficiency (kg DMI/kg LWG)*	4.6	7.9	7.2
Final weight (kg)[D]	414 ± 3.9	421 ± 3.5	418 ± 3.2
n	*50*	*50*	*50*
Hot carcass weight [1](kg)	222 ± 1.9[a]	224 ± 1.9[a]	213 ± 1.9[b]
Dressing percentage[2]	51.4 ± 0.34[a]	51.9 ± 0.24[a]	49.7 ± 0.28[b]
P8 fat depth (mm)	11 ± 0.7	9 ± 0.56	8 ± 0.6
Eye muscle area[2] (cm^2)	66 ± 0.8	65 ± 0.8	65 ± 0.9
Fat colour (intramuscular) [B]	0.54 ± 0.08	0.42 ± 0.07	0.38 ± 0.07

[A] April-Jul, including adaptation period; [B] Intake of; control diet days 14-54, molasses diets days 19-85, per pen basis. [D] day 54 for control group (n=50) estimated from linear regression, day 85 for medium molasses (n=61) and high molasses (n=60) fed animals, measured prior to slaughter. *Calculated on a per pen basis. Means in the same row for molasses fed animals with different superscripts are significantly different (*P*<0.05).

Carcass characteristics

In the first experiment, the P8 fat depth was significantly (*P*<0.05) greater for animals fed the control and medium molasses diets compared with the high molasses diet for animals slaughtered after 64 days (Table 4). There was no statistical difference in P8 fat depth between the medium and high molasses fed animals slaughtered on day 86 (Table 4).

In the second experiment the mean P8 fat depth was 11 mm for animals fed the control diet for 54 days compared to 9 mm and 8 mm for the medium and high molasses fed animals, respectively, after 85 days. There was no significant difference in P8 fat depth or intramuscular fat colour between the medium and high molasses fed animals in experiment 2.

Eye muscle area was significantly (*P*<0.05) greater for high molasses fed animals compared with control animals in experiment 1, after covariate adjustment using carcass weight (Table 4). However, this comparison could not be made in experiment 2 as control and high molasses fed animals were slaughtered after different feeding periods (Table 5).

In experiment 1, final carcass pH was similar across treatments ranging from 5.5 to 5.6. Final pH was not measured in experiment 2. There was no statistical difference in meat colour (L*, a*, b*) between treatment groups in experiment 1 for animals slaughtered on day 65.

Meat quality

Initial yield, peak force and compression were not significantly different between treatment groups in experiment 1 when slaughtered on day 65. High molasses-fed animals had significantly (*P*<0.05) higher moisture and significantly (*P*<0.05) lower intramuscular fat content than the control or medium molasses groups (Table 4). There were no detectable differences in subjective measures of eating quality between control, medium or high molasses fed animals.

Discussion

The experiments, particularly those conducted in a commercial setting, have demonstrated that live weight gains of at least 1.2 kg/d can be achieved when high molasses diets are fed. The results validated those previously obtained in animal house experiments when cattle fed 45-60% molasses in a complete diet gained over 1.2 kg/d, had commercially acceptable carcass traits and provided LD of guaranteed eating quality (Hunter, 2000). In Phase 2 experiment 1, conducted in a commercial feedlot, the live weight gain of approximately 1.3 kg/d on the high molasses diet was likely to be an underestimate of what could have been achieved had heifers been progressively adapted to the molasses diet. The logistics of the commercial feedlot dictated that all heifers were adapted to cereal grain feeding. Heifers in the molasses groups encountered substantial amounts of molasses for the first time when the experimental diets were fed; consequently it appeared from the intake data, that animals on the high molasses diet went through a further adaptation for up to nine days involving reduced intakes. The high number of animals that did not achieve the target weight within 64 days in either experimental period, particularly those fed the molasses diets, indicated diet rejection or lower than expected intakes of the molasses based diets. Calculated ME intakes from days 43 to 64 for heifers fed the high molasses diet and slaughtered at 65 d averaged 119 MJ/d and would be expected to have resulted in an ADG of 1.3kg/d. However, the variation in live weights (Figure 3), for animals fed the same experimental diet containing 29% or 50% molasses (DM basis), that contributed to an underestimate of ADG for these animals could not be explained in terms of recorded feed intakes. While these animals had an ADG of less than 1.0 kg/d, medium mature size heifers weighing 400 kg could be expected to gain 1.25 kg/d with a ME intake of 108 MJ/d (ARC, 1980). There were no indications of molasses toxicity, laminitis or digestive upsets in these animals. However, the results confirm that an adaptation period for high molasses diets is required. During the second commercial feedlot experiment, animals were specifically adapted to diets containing a high concentration of molasses. Although this resulted in consistent gains of 1.2 kg/d throughout the experimental period, it was still less than that expected based on the results obtained from the controlled animal house experiments and less than those obtained in the previous feedlot experiment where animals were fed the experimental diets for 64 days.

High molasses diets are associated with a decrease in fat depth at the P8 rump site. The reduction in P8 fat depth associated with the high molasses diet in this experiment was similar to results previously reported with high molasses diets (Hunter, 2000). In these experiments, the higher the molasses inclusion rate in the diet, the lower the P8 fat depth. The mechanism by which this reduced deposition of subcutaneous fat occurs is not clear. Results indicated that the inclusion of molasses at 29% or 50% (DM basis) in a feedlot diet has the potential to produce leaner beef without affecting meat quality and achieve live weight gains of between 1.2 and 1.7 kg/d. This information is important at times of high grain prices, as it allows feedlot managers to formulate diets with a reduced feed cost per unit live weight gain.

There was a discrepancy in the relative live weight gain of the cattle on grain based and high molasses diets between the controlled animal house and the commercial feedlot experiments. In the animal house experiments live weight gains were 0.1 and 0.2 kg/d less on the high molasses diets than on the high grain sorghum diet. This can be explained in terms of energy density of the diets, feed intakes and feed conversion efficiencies (Table A2 and Table 3). Feed intake was higher on the high grain sorghum diet, but feed conversion to live weight gain was more efficient on the high molasses diet. It can be calculated from feed intakes and conversion efficiencies presented in Table 3 that daily gains for a 400 kg steer could have been 1.2 and 1.3 kg/d for the 60% molasses and the 55% grain sorghum diets, respectively. Similar calculations for a 350 kg heifer result in expected daily live weight gains of 1.2 and 1.8 kg/d which are comparable to the measured gains for animals fed the high molasses and control diets, respectively in the second feedlot experiment. The main influencing factors in the differences in daily gain between high grain and high molasses diets in the second feedlot experiment were the divergence in feed conversion efficiencies (7.2 *vs.* 4.6). Differences of this magnitude are also evident in the first feedlot experiment. In the controlled animal house experiments, there was a tendency for feed to be converted into gain more efficiently on the high molasses diets. The complete reverse was apparent in the feedlot experiments. A combination of different lengths of the feeding period on different diets in the feedlot experiments, different base energy ingredients (barley, maize, the addition of bakery wastes), molasses from different sources (Bundaberg *vs.* Mackay) or different relative supply or composition of mineral supplements may have contributed to the observed differences.

5. Success in achieving objectives

Phase one of the project, "Evaluation of high molasses diets in commercial feedlot operations", clearly demonstrated that liveweight gains of up to 1.8 kg/d could be achieved when dietary molasses constituted 45-60% of the diet on a DM basis when fed to cattle with an initial live weight of 400 kg.

Good carcass composition, white fat and acceptable meat colour is achieved when molasses is fed at high levels. In addition, MSA consumer taste testing panels have confirmed that meat-eating quality is not compromised when high molasses diets are fed to steers in an animal house.

The initial results from phase one indicated that molasses could be substituted for grain in a conventional grain-based feedlot diet with only a small decrease expected in average live weight gains. The commercial validation phase in a feedlot confirmed that the technology is robust and readily adopted by the commercial sector.

Phase two of the project clearly demonstrated that live weight gains of between 1.2–1.7 kg/d could be achieved when dietary molasses constituted 29% or 50% of the diet on a DM basis, respectively, when fed to cattle with an initial live weight of 323 kg.

Carcass characteristics and meat quality were measured. Good carcass composition, white fat and acceptable meat colour have also been measured when molasses is fed at high levels in a commercial feedlot. MSA consumer taste testing panels have confirmed that meat-eating quality is assured when high molasses diets are fed to steers managed under commercial conditions.

An economic assessment comparing high and medium molasses, and conventional diets is presented Tables A6 and A7. The assessment assumes a conventional grain based feedlot diet to contain 72.5% grain as the principal energy source on an as fed basis, current and fluctuating grain prices ($200 to $ 280 per tonne) and molasses, landed at a feedlot, from $70 to $130 per tonne.

Impact on feedlot sector

High molasses diets are potentially useful in the northern beef industry and could be used to assure consistency of supply of cattle with guaranteed eating quality. A small number of feedlots are currently using higher than normal (10%) inclusion rates of molasses in the diet when high grain prices are forecast, but this does not constitute a large or assured demand. The technology is not a replacement for conventional grain in all feedlots, but is seen as a viable strategy in northern Australia, particularly in areas close to sugar mills, and feedlots targeting premium beef markets.

Results to date suggest that an alternative energy source such as molasses, in a feedlot diet, has the potential to reduce production costs of finishing beef cattle and produce leaner beef without affecting meat quality.

6. Conclusions

This study has shown that commercially attractive live weight gains and acceptable eating quality can be achieved with high molasses diets. Such diets could underpin an intensive cattle-finishing industry in northern Australia.

7. Recommendations

- That the outputs of this project be made available to potential users of the technology
- That the outputs generated from this work be used to initiate discussions between the northern Australian intensive cattle feeding sector and the Queensland sugar industry.

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9. Appendix 1. Additional data

Table A.1 Phase experiment 1 & 2. Ingredients of experimental diets (% dry matter) and calculated nutrient composition.

Molasses	**30.0**	**45.0**	**60.0**	**72.5**
Cotton seed	20.0	20	20	20
Cotton seed meal	5.0	3.7	4.1	4.5
Urea	1.5	1.5	1.5	1.5
Fibremax®	42.0	28.3	12.9	0
Minerals	1.5	1.5	1.5	1.5
Nutrient composition				
Crude protein (g/kg)	135	136	143	149
Metabolisable energy (MJ/ kg DM)	9.3	9.8	10.5	11.0

Table A.2 Phase 1 experiment 4. Ingredients of experimental diets, molasses: grain sorghum ratio (% dry matter) and calculated nutrient composition.

	60 : 0	**40 : 20**	**20 : 40**	**5 : 55**
Molasses	60	40	20	0
Sorghum	0	20	40	60
Cotton seed	10	10	10	10
Fibremax®	10.6	12.8	15.0	16.6
Cotton seed meal	17.4	15.2	13.0	11.4
Urea	0.5	0.5	0.5	0.5
Minerals	1.5	1.5	1.5	1.5
Nutrient composition				
Crude protein (g/kg)	140	136	133	131
Metabolisable energy (MJ/ kg DM)	10.8	10.9	11.0	11.0

Table A.3 Phase 2 experiment 1. Ingredients of feedlot diets (% dry matter) and calculated nutrient composition.

	Starter	Intermediate	Control	Medium Molasses	High Molasses
Component of diet					
Barley grain	43.0	30.0	47.5	38.0	-
Cane molasses	12.0	10.0	1.0	29.0	50.0
Whole Cotton seed	7.0	7.5	9.0	22.0	18.0
Cotton seed meal	1.5	1.5	-	-	5.0
Lucerne hay	20.0	8.5	-	3.0	19.0
Blended oils	-	1.0	2.0	-	-
Silage	10.0	10.0	8.5	-	-
Bakery waste	-	25.0	25.0	-	-
Dry starter supplement	6.5	3.0	-		
Liquid mineral supplement[1]	-	3.5	7.0	8.0	8.0
Nutrient composition					
Dry matter (g/kg)	822	753	765	820	810
Crude protein (g/kg DM)	135.6	136.7	134.8	138.4	125.2
Metabolisable energy (MJ/kg DM)	11.09	12.02	12.84	12.11	10.58

[1]feedlot preparation

Table A.4 Phase 2 experiment 2. Ingredients of feedlot diets (% dry matter) and calculated nutrient composition.

	Starter	Intermediate	Control	Medium Molasses	High Molasses
Component of diet					
Feed maize	35.0	42.0	46.0	38.0	-
Cane molasses	9.0	3.5	1.0	29.0	50
Whole Cotton seed	7.0	7.5	7.0	22.0	23.0
Cotton seed meal	-	-	-	-	-
Lucerne hay	30.0	20.0	1.0	3.0	19.0
Blended oils	-	-	-	-	-
Bakery waste	-	10.0	30.0	-	-
Silage	10.0	10.0	10.0	-	-
Dry starter supplement	9.0	4.7	-	-	-
Liquid mineral supplement[1]	-	2.3	5.0	8.0	8.0
Nutrient composition					
Dry matter (g/kg)	784	722	691	820	810
Crude protein (g/kg DM)	136	136	136	138	125
Metabolisable energy (MJ/kg DM)	10.8	11.5	12.4	12.1	10.6

[1]feedlot preparation

Table A.5 Slaughter floor electrical inputs

	Shackle	L/V Stimulator	Hide stripper
Voltage (V)	200	200	50[1]
Current (ma)	400	300	N/a
Frequency (m/sec)	N/a	N/a	4.4
Duration (sec)	5	Nil	variable

[1]direct current. N/a not applicable

Table A6. The estimated cost of a conventional grain based (C) and medium (M) or high (H) molasses diet when molasses and grain prices vary1 ($/tonne).

			Molasses ($/tonne)						
			70	80	90	100	110	120	130
Grain ($/tonne)	200	C	200.41	200.51	200.61	200.71	200.81	200.91	201.01
		M	177.28	180.18	183.08	185.98	188.88	191.78	194.68
		H	153.62	158.62	163.62	168.62	173.62	178.62	183.62
	210	C	207.66	207.76	207.86	207.96	208.06	208.16	208.26
		M	181.08	183.98	186.88	189.78	192.68	195.58	198.48
		H	153.62	158.62	163.62	168.62	173.62	178.62	183.62
	220	C	214.91	215.01	215.11	215.21	215.31	215.41	215.51
		M	184.88	187.78	190.68	193.58	196.48	199.38	202.28
		H	153.62	158.62	163.62	168.62	173.62	178.62	183.62
	230	C	222.16	222.26	222.36	222.46	222.56	222.66	222.76
		M	188.68	191.58	194.48	197.38	200.28	203.18	206.08
		H	153.62	158.62	163.62	168.62	173.62	178.62	183.62
	240	C	229.41	229.51	229.61	229.71	229.81	229.91	230.01
		M	192.48	195.38	198.28	201.18	204.08	206.98	209.88
		H	153.62	158.62	163.62	168.62	173.62	178.62	183.62
	250	C	236.66	236.76	236.86	236.96	237.06	237.16	237.26
		M	196.28	199.18	202.08	204.98	207.88	210.78	213.68
		H	153.62	158.62	163.62	168.62	173.62	178.62	183.62
	260	C	243.91	244.01	244.11	244.21	244.31	244.41	244.51
		M	200.08	202.98	205.88	208.78	211.68	214.58	217.48
		H	153.62	158.62	163.62	168.62	173.62	178.62	183.62
	270	C	251.16	251.26	251.36	251.46	251.56	251.66	251.76
		M	203.88	206.78	209.68	212.58	215.48	218.38	221.28
		H	153.62	158.62	163.62	168.62	173.62	178.62	183.62
	280	C	258.41	258.51	258.61	258.71	258.81	258.91	259.01
		M	207.68	210.58	213.48	216.38	219.28	222.18	225.08
		H	153.62	158.62	163.62	168.62	173.62	178.62	183.62

[1]Other costs for roughage, mineral supplements and cottonseed meal or whole cottonseed are fixed. Diet composition is based on feedlot diets used in phase 2, experiments 1 and 2. Estimated cost assumes delivered on farm.

Table A7. The estimated cost of live weight gain ($/kg ADG) for conventional grain based (C) and medium (M) or high (H) molasses diets[1]

			Molasses ($/tonne)						
			70	80	90	100	110	120	130
Grain ($/tonne)	200	C	1.45	1.45	1.45	1.45	1.45	1.45	1.45
		M	1.49	1.52	1.54	1.57	1.59	1.62	1.64
		H	1.46	1.51	1.55	1.60	1.65	1.70	1.74
	210	C	1.50	1.50	1.50	1.50	1.50	1.50	1.50
		M	1.53	1.55	1.58	1.60	1.62	1.65	1.67
		H	1.46	1.51	1.55	1.60	1.65	1.70	1.74
	220	C	1.55	1.55	1.55	1.55	1.55	1.55	1.55
		M	1.56	1.58	1.61	1.63	1.66	1.68	1.70
		H	1.46	1.51	1.55	1.60	1.65	1.70	1.74
	230	C	1.60	1.60	1.60	1.60	1.60	1.61	1.61
		M	1.59	1.61	1.64	1.66	1.69	1.71	1.74
		H	1.46	1.51	1.55	1.60	1.65	1.70	1.74
	240	C	1.65	1.65	1.66	1.66	1.66	1.66	1.66
		M	1.62	1.65	1.67	1.70	1.72	1.74	1.77
		H	1.46	1.51	1.55	1.60	1.65	1.70	1.74
	250	C	1.71	1.71	1.71	1.71	1.71	1.71	1.71
		M	1.65	1.68	1.70	1.73	1.75	1.78	1.80
		H	1.46	1.51	1.55	1.60	1.65	1.70	1.74
	260	C	1.76	1.76	1.76	1.76	1.76	1.76	1.76
		M	1.69	1.71	1.74	1.76	1.78	1.81	1.83
		H	1.46	1.51	1.55	1.60	1.65	1.70	1.74
	270	C	1.81	1.81	1.81	1.81	1.81	1.81	1.82
		M	1.72	1.74	1.77	1.79	1.82	1.84	1.87
		H	1.46	1.51	1.55	1.60	1.65	1.70	1.74
	280	C	1.86	1.86	1.86	1.87	1.87	1.87	1.87
		M	1.75	1.77	1.80	1.82	1.85	1.87	1.90
		H	1.46	1.51	1.55	1.60	1.65	1.70	1.74

[1]Based on feedlot diets and levels of animal productivity described in phase 2. Calculations based on as fed intakes of 13.7, 11.8 and 11.4 kg/d and average daily gains on a pen basis of 1.9, 1.4 and 1.2 kg/d for a conventional, medium or high molasses diet, respectively.

10. Appendix 2. Scientific and media publications

High Molasses Diets for Intensive Finishing of Steers

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The traditional view of molasses in northern Australia is that it is a useful feedstuff for survival feeding, low-grade energy supplementation and as a vehicle for the delivery of protein and mineral supplements. Yet molasses is a very palatable energy-dense feedstuff (11 MJ of ME/kg dry matter(DM)) and has the potential to be the basis of highly productive diets for intensively finishing cattle to market specifications. Previous research in the Carribean demonstrated that with diets of about 90% molasses, weight gains of about 0.7 kg/d could be achieved. Potential benefits would be greater if high levels of molasses could be incorporated into diets that achieved liveweight gains approaching that achieved on traditional feedlot diets.

Thirty-two high grade Brahman steers of initial weight 299 ±4.8kg (mean ± SEM) were housed in individual pens in a roofed animal house. They were allocated to 4 groups of 8 steers on the basis of liveweight. Groups were allocated randomly to one of 4 diets: 30, 45, 60 and 72.5 % molasses (DM basis). Diets were formulated to contain approximately 14 per cent crude protein per kg DM. Components of the diets were molasses, whole cotton seed at 20% of the DM, cotton seed meal, urea fixed at 1.5 %, Fibremax (alkali treated bagasse) and a mineral mix at 1.5 %. The steers were fed the experimental diets *ad libitum* for 175 days; 35 days preliminary feeding and 140 days during which feed intakes and growth rates were measured. All steers were implanted with Compudose®100 on day 36 and again 80 days later. Steers were weighed once a week, 24 hours after feeding. Feed residues were weighed daily. At slaughter trained staff collected AusMeat and Meat Standards Australia data. Representative tissue samples from one steer were subjected to testing for chemical residues. Eating quality of the *longissimus dorsi muscle* was determined as a meat quality score (CMQ4) by consumer sensory panels (Polkinghorne *et al.* 1999). CMQ4(0-100) combines consumer ratings for the tenderness, juiciness, flavour and overall acceptability of grilled steaks into a single score.

There were no indications of molasses toxicity. laminitis or digestive upset in any animal. No chemical residues were found in the carcass sampled. All dietary formulations were associated with liveweight gains in excess of 1 kg/d and acceptable feed conversion efficiencies (Table 1), suggesting that high molasses diets are potentially useful for intensive finishing of cattle to premium market specifications. Consumers found steaks of acceptable eating quality. A MQ4 score of 57 for the 45% molasses group equates to a score of 56 which was recorded for the Meat Quality CRC Brahman steers of similar liveweight finished on a grain based diet in a feedlot.

Table 1. Productivity and eating quality of steers fed molasses based diets (data analysed with initial weight[1] or carcass weight[2] as a covariate)

	30 %	45%	60%	72.5 %	SEM
DMI[1] (g/kgLWd)	24[a]	24[a]	23[a]	16[b]	0.9
LW gain[1] (kg/d)	1.3	1.5	1.6	1.3	0.11
FCE[1] (kgDMI/kgLW gain)	8.3[a]	7.2[b]	6.5[b]	5.5[c]	0.23
Final LW[1] (kg)	494	523	537	498	14.6
Carcass wt[1]. (kg)	261	282	287	256	4.5
Dressing %[2]	53	53	53	52	0.5
P8 fat depth[2] (mm)	15	15	12	11	1.8
Eye muscle area[2] (cm^2)	68	72	71	63	2.6
Tenderness[2]	46	61	51	51	5.6
Juiciness[2]	50	58	53	54	4.0
Flavour[2]	51	55	54	50	4.3
Overall acceptance[2]	50	58	53	47	4.8
CMQ4 score[2]	49	59	52	49	4.6

Means with different superscripts differ significantly $P<0.05$, DM, dry matter; DMI, dry matter intake; LW, liveweight; FCE, feed conversion efficiency

This study has shown that commercially attractive liveweight gains and acceptable eating quality can be achieved with high molasses diets. Such diets could underpin an intensive cattle finishing industry in northern Australia.

Polkinghorne, R., Watson, R., Porter, M., Gee, A., Scott, J. and Thompson, J. 1999. Meat Standards Australia, a"PACCP" based beef grading system for consumers. 1. The use of consumer scores to set grade standards. Proceedings of the 45th International Congress of Meat science and Technology, Yokohama, Japan. 45: 14-15.

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High Molasses Feeding of Intensively Finished Beef Cattle: An Economic Analysis

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ABSTRACT: An economic evaluation of an intensive molasses based finishing system was undertaken using two levels of performance (1.3 and 1.5 kg/d) and commercial cost and price structures. Breeder numbers were increased by 20% when a 2500 adult equivalent herd was changed from a 3-4 year old grass finishing system to an intensive molasses based finishing system producing predominantly 2 year old steers. Depending on liveweight performance, molasses prices up to $120/t resulted in an increased herd gross margin (GM) of up to 9.5% greater than the 3-4 year old grass fed system. An improvement in animal performance from 1.3 to 1.5 kg/d increased herd GM by at least 2.7%. Herd GM decreased as molasses price increased. Calculations indicated that properties within 480 km of molasses sources could profitably use this technology to improve the value of finished cattle. This work has implications for the development of an intensive finishing sector in northern Queensland.

Key Words: Beef Cattle, Intensive Finishing, Molasses, Economic Analysis

INTRODUCTION

Markets for the northern Australian beef industry are changing. Exports of manufacturing beef to the USA are fluctuating while there is increasing demand for quality beef products from Asian markets. Asian beef markets demand continuity of supply of product within tight specifications that are not always possible to achieve under extensive grazing, given the erratic seasonality of northern Australia. To be able to provide a reliable supply of product to these markets throughout the year, a period of intensive feeding of cattle for rapid weight gain maybe necessary.

There are more than one million tonnes of molasses produced by Queensland sugar mills each year. About 600,000 tonnes of this supply are exported, and only 150,000 tonnes are used for feeding domestic livestock. Much of the exported product could be sold on the domestic market if there was an assured demand. The common stockfeed uses for molasses are for inclusion in grain-based feedlot diets at low levels (<10%), for survival feeding during drought and as a carrier for protein and mineral supplements.

Molasses is a cheaper source of energy in cattle diets in tropical areas than other more conventional energy dense feeds such as cereal grains (eg. molasses $0.71 per 100MJ, sorghum $1.42 per 100MJ). Based on the data of Hunter (2000), we have calculated that if 500,000 tonnes of molasses were available annually and represented 50% of the diet of intensively fed cattle, then it would be possible to add 100 kg of liveweight to approximately 1.3 million head of cattle. The potential benefits from incorporating high levels of molasses in productive diets are substantial. If an intensive feeding industry were developed in northern Queensland, it would be pivotal to continuity of supply of cattle and beef into Asian markets.

Molasses feeding at pasture has been practiced since research and validation at commercial sites indicated its usefulness as a value-adding tool for grazing cattle (Lindsay *et al.* 1996, 1998). Molasses based feeding technology has primarily used high (>2.5%) urea concentration molasses mixes, sometimes combined with 10% grain. The gains obtained from this ration have often been c. 0.7-0.8 kg/d (Lindsay *et al.* 1998) which perhaps were associated with substitution effects from ingested forage. Recent feedlot work conducted at Rockhampton (Hunter 2000), using complete molasses based rations with high levels (>15%) of protein sources and low (<1.5%) urea concentrations, provided daily gains of 1.3-1.6 kg/d.

The economic evaluation of intensive molasses feeding technology was undertaken using data obtained from the molasses feeding work conducted at CSIRO Rockhampton. The thrust of such technology is to allow an improvement in product value and business return with the possibility of reducing existing grazing pressures.

MATERIALS AND METHODS

The Herd

A base herd of 2500 adult equivalents (AE) (c. 1200 joined females) was used to evaluate economically the intensive molasses based finishing system. This herd produced grass-fed steers of 3-4 years of age. The herd parameters used for the modelling activity included a low weaning rate of 55% (weaners/total joined females) (Bortolussi *et al.* 1999a, 1999b) and a mean female mortality rate of 4% (G Bortolussi unpublished data). Non-pregnant heifers were culled post mating in the 2-3 (40%) and 3-4 (25%) year old age groups as is industry practice (Bortolussi *et al.* 1999a, 1999b). Limited numbers (n<5) of weaner heifers were sold to balance the herd adult equivalents. Operating costs for the herd were derived from industry estimates. Meatworks were consulted and the price relativity of various markets was established, based on carcass weight, fat depth and dentition.

The Analysis

The finishing systems were evaluated using the Bcowplus steady state model, one of the components of the Breedcow-Dynama suite of herd models (Holmes 1999).

The Finishing System

The finishing system evaluated is representative of large areas of northern Australia where the annual liveweight gain of steers is in the range 120-150 kg/year gains. It was assumed that the starting point for each modelling exercise was a 6 month old weaner (170kg) that was subject to recommended post-weaning dry season supplementation practice (Bortolussi *et al.* 1999a, 1999b).

The feeding exercise evaluated used the 60% molasses ration, described by Hunter (2000), since it provided the best liveweight performance. Two average daily gains (1.3 and 1.5 kg/d) were used to assess the financial performance of the finishing system. A gain of 1.5 kg/d was used since it is very close to the 1.6 kg/d gain obtained by Hunter (2000).

Although there are approximately 150 days available for feeding from July (when molasses becomes available) to November (when demand for finished cattle is high) an average feeding period of 120 days was used. Cattle finished with molasses based complete diets were not at pasture.

Two finishing systems were considered:

1. A pasture only production system (3-4 yo Grassfed) was used as the base for comparison with the molasses based finishing system. With pasture finishing, 40% of steer turn-off graded as USA (@ $2.10/kg carcass weight) and 60% graded as Japanese (6 teeth) (@ $2.35/kg carcass weight). An average finished liveweight of 555 kg was used since the data of Bortolussi *et al.* (1999a, 1999b) indicated that Japanese market steers had a mean liveweight of *c.* 580kg and USA market steers *c.* 520kg. Average finished steer value was $665 with 6-tooth dentition (38-42 months). 10% of the 3 year old steers were sold off to account for the lead of that age group often being ready for sale in the May-September period.
2. Intensively fed yearling (18-20 month old; 350-365kg) steers (2 yo 80% fed). Of the 80% of total steers fed under this system, 60% graded as Japanese/EEC (2 teeth) (@$2.42 kg carcass weight), 20% graded as USA (@ $2.10 kg carcass weight) and 20% graded as Korean (@ $2.37 kg carcass weight). Average steer value was $690 with 2-tooth dentition. Of the remaining 20% of steers, half were sold as 3 year olds and the balance sold at 4 years of age similar to the grass-fed finishing system.

Steers from the 1.3 kg/d feeding exercise were sold at 555kg ($690/hd). Two scenarios were evaluated with 18-20 month old steers gaining 1.5 kg/d when fed the complete molasses ration. Steers gaining 1.5 kg/d were disposed of at either 555 kg (102 days feeding, $690/hd) or 584 kg (120 days feeding, $726/hd). This exercise was intended to assess the advantage of feeding for additional liveweight superiority over the grass fed base

Based on field observations (G Bortolussi, unpublished data), 80% of the steers in the 1-2 year old class were chosen since some animals would be rejected on the basis of being non-performers on the diet or being too light to finish economically. Animals not fed in the first group were not fed in subsequent years. The finishing strategy was not applied to the cull heifers despite it being a common strategy, given certain market options for heifer carcasses. No allowance was made for improved performance in the remaining steers grazing at markedly lower stocking rates. HGP implants were not incorporated into the modelling for animal performance. The costs of the ration ingredients were obtained from commercial sources. Prices landed on property were molasses ($50-150/t), whole cottonseed ($160/t), cottonseed meal ($380/t), urea ($520/t) and a sugar cane bagasse product, Fibremax® (Fibretech Developments Ltd, $154/t).

The prices received for livestock and operating costs of the various classes of livestock are outlined below in Table 1

Table 1. Sale prices, husbandry costs and adult equivalent (AE) ratings of various classes of cattle.

Age Class	Sale Price ($)	Husbandry cost ($)	AE Rating
Weaners to 1 yr	170	22.50	0.40
Heifers 1-2 yr	320	12.00	0.70
Heifers 2-3 yr	470	12.00	1.00
Cows 3+ yrs	450	14.00	0.99
Bulls	850	15.00	1.43
Steers 1-2 yr	Not sold	7.00	0.75
Steers 2-3 yr	Not Sold	7.00	1.05

In addition to the above, steers older than 3 years of age had an average adult equivalent (AE) rating of 1.5 and annual base husbandry costs of $6 per head. Sale price is given in Table 1. The AE rating used for pregnancy and lactation was an additional 0.35.

Sensitivity Analysis

Since molasses is the major component of the ration and price can vary widely, the sensitivity of herd GM was tested in relation to a range of molasses prices ($50-150/t landed on property). Cattle price fluctuations were not accounted for since processing sector sources advised that price relativity between premium markets and US manufacturing tended to be fairly stable at *c.* 20c/kg, despite price fluctuations.

The sensitivity analysis also encompassed the economic effects of the two rates of gain 1.3 and 1.5 kg/d in the finishing system.

The aim of this analysis was to compare the GM from an intensive molasses based finishing system with the more traditional grass finishing system. The molasses based finishing system was intended to turn off younger steers in the last quarter of the year when there is a price premium associated with a shortage of finished cattle.

RESULTS AND DISCUSSION

Depending on molasses price and daily gain, the high molasses finishing regime increased herd GM by up to 9.5% when compared with the base grass fed steer system (Table 2). Movements in herd GM tended to reflect movements in molasses price.

The improvement in daily gain from 1.3 to 1.5 kg/d in the 120d finishing system improved herd GM by at least 2.7%. However, the comparison of turn-off options (102 *v.* 120d finishing periods) in the 1.5 kg/d system indicated that there was little advantage in shortening the feeding period since the relative returns between the two options were very similar as they differed by <1% in herd GM. However, depending on molasses cost, the shorter feeding period with a gain of 1.5 kg/d had herd GM 2.7-4.6% higher than the 1.3 kg/d scenarios.

The improvement in herd GM using intensive molasses based feeding is attributed to the movement of increased numbers of sale stock to more premium (younger & higher price per kg carcass weight) markets and the higher overall turnover. Female sales contributed similarly to sales receipts in each system.

Table 2. Herd Gross Margin (GM) changes with changes in molasses price, feeding period and daily gain from a 2500 AE herd using an intensive molasses finishing system.

Molasses ($/t)	Herd GM ($) @1.3 kg/d	% over base	Herd GM ($) @1.5 kg/d	% over base	Herd GM ($) @1.5 kg/d	% over base
Grass-fed Base Herd	$294,729	-	$294,729	-	$294,729	-
Feeding Period (days)	120		120		102	
$50	$313,713	6.4	$322,716	9.5	$322,057	9.3
$90	$301,509	2.3	$309,987	5.2	$311,682	5.8
$100	$298,458	1.3	$306,848	4.1	$309,089	4.9
$120	$292,355	-0.8	$300,438	1.9	$303,901	3.1
$150	$283,202	-3.9	$290,893	-1.3	$296,122	0.5

There were herd structural changes associated with the change in finishing system and hence younger turn-off (Table 3). A 20% increase in joined female numbers was required in the move from a 3-4 year old finishing system to the 2-year-old turn-off finishing system. Although total adult equivalents carried remained at 2500, total numbers carried in the 2-year-old system were reduced by only 1.5%. This was because of increased female numbers and steers subjected to intensive finishing were only removed from pasture for *c.* 3 months before transport from the property to slaughter.

Such a radical reduction (up to 2 years) in turn-off age has significant implications for overall herd dynamics. An extended adjustment period, particularly to build up female numbers, may be required before the turn-off age can be permanently reduced to 2 years old.

Table 3. Herd structural changes accompanying the turn-off strategies for the 2500 AE herd.

System	Joined Females	Steers Fed	Total Steers Sold	Total Sales	Total Head
3-4 yo Grassfed	1225	-	320	612	2700
2 yo 80% fed	1475	314	391	742	2658

Grazing pressures on northern rangeland communities are regarded as being high (Gardener *et al.* 1990; Tothill & Gillies, 1992). The modelling outcomes indicate that there is some scope to reduce herd size and thus overall grazing pressure whilst maintaining herd GM. However, the liveweight performance in the molasses based finishing system will have to be greater than 1.3kg/d combined with landed molasses costs of <$90/t to allow beef businesses to take full advantage of any opportunity to reduce total numbers carried.

The development of such finishing systems could result in substantial increase in domestic demand for molasses. The likely effect of this on price is beyond the scope of this paper.

Recently molasses has been available at mills for between $45 and 60/t. Using a mean price of $50/t at mill and transport costs of $2.70/km (single semi-trailer tanker), we calculated that 480 km was the maximum distance from a sugar mill that molasses could be landed at less than $100 per tonne. The use of larger capacity (B double) tankers could extend the range to *c.* 550 km. These distances put a potentially large proportion of the northern Black Spear grass community within reach of such technology.

However, given the marginal nature of the improvement in herd GM at $100/t and 1.3 kg/d gain it is more likely that finishing activities would be conducted closer to mill districts. This has implications for the feasible development of a potentially specialised intensive finishing sector in northern Queensland and other areas of northern Australia where the sugar industry is expanding.

This analysis represents an almost worst case scenario where no premiums are paid for younger cattle of assured eating quality. In addition to this, a lower than expected (1.3 kg/d) finishing liveweight performance was used, thus extending the required feeding period. However, it is notable that given these worst case assumptions, the system can still generate similar or greater business returns at molasses prices up to $120/t than a grass fed finishing system producing older steers.

We expect that the financial performance of the molasses based finishing system would be enhanced with its application to cull heifers and the additional use of hormonal growth promotants and crossbreeding which would provide improved liveweight performance.

IMPLICATIONS

Large areas of northern Queensland have pasture communities that have difficulty in producing annual liveweight gains of >120 kg. This results in the production of predominantly lighter grass fed steers (*c.* 555 kg) similar to those evaluated in this paper. Therefore, the feeding of molasses based complete diets has a role to play in the development of intensive finishing strategies for northern Australia where the goal is to produce young cattle for premium markets. On the basis of this being a conservative analysis, intensive molasses feeding appears to have a viable role in enhancing the value of a traditionally lower value product from cattle grazing tropical rangeland communities. However, price of molasses and performance of finishing cattle will have a marked impact on margins.

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HIGH MOLASSES DIETS FOR FEEDLOT CATTLE

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SUMMARY
This experiment investigated the effect of high molasses diets on feed intake, growth rate, carcass traits and meat eating quality of *Bos indicus* cross cattle under commercial feedlot conditions. Heifers were allocated to 1 of 3 groups and fed feedlot diets containing 1, 29% or 50% molasses on a DM basis. Average daily DM intake for the first 64 days was 23-24 g/kg liveweight for each of the treatment groups. The inclusion of molasses in the diet reduced ($P<0.05$) average daily gains (ADG) (control, mid and high molasses groups; 2.1 ± 0.04, 1.7 ± 0.05 and 1.3 ± 0.06 kg/d, respectively). The P8 fat depth was lower ($P<0.05$) for animals fed the high molasses diet (4.2 ± 0.5 mm) than the control and mid molasses groups (6.9 ± 0.5 and 5.8 ± 0.5 mm, respectively). Objective and subjective measures of meat quality were found to be similar between cattle fed a conventional grain-based diet and medium and high molasses diets. The inclusion of molasses at 29 or 50% (DM basis) in feedlot diets could result in acceptable ADG and produce leaner beef without affecting meat quality.

Keywords: molasses, beef cattle, feedlot, Northern Australia

INTRODUCTION
High molasses diets for cattle were pioneered in Cuba in the 1960s (Preston *et al.* 1967). In northern Australia, molasses has traditionally been seen as an energy supplement, and a medium for delivering non-protein nitrogen. Although molasses is a palatable energy-dense feedstuff (11 MJ metabolisable energy/kg DM) with potential to form the basis of high production diets in feedlots near sugar cane growing areas, it is currently fed at low levels (<10%) in grain-based feedlot diets. The inclusion of molasses at high levels (60% DM basis) in feedlot diets resulted in gains of 1.6 kg/d when fed to housed Brahman steers (Hunter 2000). Molasses is generally a cheaper energy source than other energy-dense feeds such as grains (Bortolussi and Hunter 2000). It would be feasible to add 100 kg of liveweight to approximately 1.3 million head of beef cattle if 0.5 million tonnes of molasses were available per year, and constituted 50% (DM basis) of the diet of feedlot cattle (Hunter 2000). This experiment investigated the commercial reality of feeding high molasses diets to feedlot cattle.

MATERIALS AND METHODS
Experimental animals, design and diets
The experiment was conducted at a feedlot in the Brisbane Valley, Queensland. In all, 270 *Bos taurus* x *B. indicus* heifers (mean ± s.e.m. initial liveweight (LW); 325 ± 2.3 kg) were randomly allocated using a 3-way draft to 1 of 3 treatment groups, 1 group per pen. All animals were adapted to a high-grain feedlot diet by feeding a starter diet consisting of barley grain, hay, silage and molasses (Table 1) for 6 days and an intermediate diet consisting of barley grain, bakery waste, silage and molasses for a further 6 days. Three experimental diets that contained 1, 29 or 50% molasses, and 9, 22 or 18% whole cottonseed, respectively, on a DM basis, were fed from day 13 (Table 1). A liquid mineral supplement prepared by the feedlot was included in the experimental diets to satisfy calium, phosphorus and sodium requirements. Diets were offered at a rate to ensure minimum wastage. Mean individual intakes, per pen basis, were estimated throughout the experiment. Liveweight was measured at induction and on days 43, 64 and 85. Eighty-eight control animals and 45 animals from each of the other treatment groups were slaughtered on day 65, when LW was 360-440 kg. Animals that did not reach a commercially determined LW at day 64 were retained until an average LW of 428 ± 5.1 kg was measured on day 86, after which they were slaughtered.

Slaughtering and processing
Heifers were transported by road (<2h), held for 14-16 h in lairage, and slaughtered in their separate treatment groups. Electrical stimulation was not applied immediately after exsanguination. In the first slaughter (at day 65), carcass characteristics (carcass weight, P8 fat depth, eye muscle area (EMA) and subcutaneous fat colour at slaughter) were recorded for all animals. Eighteen, 20 and 19 carcasses were randomly sampled from the control, mid and high molasses groups, respectively, to measure

objective and subjective determinants of meat quality. Carcass pH and temperature decline were also measured over a 10 h period. From each carcass, 1 *M. longissimus dorsi* (LD) was boned-out 24 h post-slaughter, and separated into cranial and caudal sections. Individual sections were vacuum packed and held at –0.5°C for 5 h. Caudal and cranial sections were transported directly to Meat Standards Australia (MSA, Armidale, NSW) or Food Science Australia (FSA, Cannon Hill, Qld), respectively. All samples were aged for 7 d and stored frozen at -20°C before determination of subjective meat quality by MSA, and objective determination of meat quality by FSA. In the second slaughter (at day 86), carcass traits (carcass weight, P8 fat depth, EMA and subcutaneous fat colour at slaughter) were recorded for all animals.

Table 1. Composition of feedlot diets offered to Brahman cross heifers (% total diet DM).

Component of diet	Starter	Intermediate	Control	Mid Molasses	High Molasses
Barley grain	43.0	30.0	47.5	38.0	-
Cane molasses	12.0	10.0	1.0	29.0	50.0
Whole Cotton seed	7.0	7.5	9.0	22.0	18.0
Cotton seed meal	1.5	1.5	-	-	5.0
Lucerne hay	20.0	8.5	-	3.0	19.0
Blended oils	-	1.0	2.0	-	-
Silage	10.0	10.0	8.5	-	-
Bakery waste	-	25.0	25.0	-	-
Dry starter supplement	6.5	3.0	-		
Liquid mineral supplement	-	3.5	7.0	8.0	8.0

Measurements of meat quality

Cranial portions of LD were used to determine objective measures of meat quality after being cooked in a water bath for 60 mins at 70°C. Analyses included Warner-Bratzler shear force, compression, moisture (Harris and Shorthose 1991), minolta colour (L*, a*, b*) and intramuscular fat content. Caudal sections were used for subjective determination of flavour, tenderness and juiciness to determine meat quality scores (MQ4) for each group by MSA taste panels (Polkinghorne *et al.* 1999).

Statistical analyses

Analysis of variance, using the general linear models (GLM) procedure of SAS (1996) with Duncan's multiple range test was used to determine significant differences ($P<0.05$) between treatment means within slaughter groups. Where valid, initial and carcass weights were used as covariates for analysis of productivity and objective meat quality measures, respectively. Animals weighing less than 370 kg at day 85 were retained by the feedlot and excluded from statistical analysis.

RESULTS

Average daily intakes for each treatment group were 23-24 g/kg LW for the first 64 d. Linear regression analysis indicated that mean (± s.e.m.) daily gains were 2.1 ± 0.04, 1.7 ± 0.05 and 1.3 ± 0.06 kg for the control, mid and high molasses groups over 64 d, respectively (Figure 1), which were significantly different (Table 2). Average daily gains were not different for the mid and high molasses-fed animals that were carried over to 85 days (Table 2). The LW measured on day 64 of the high molasses fed animals was significantly ($P<0.05$) less than those achieved by the control and mid molasses fed animals (Table 2). Nine and 10 animals from the mid and high molasses groups, respectively, did not reach the specified slaughter weight within 85 days.

The P8 fat depth was greater for animals fed the control and mid molasses diets compared with the high molasses diet for animals slaughtered after 64 days (Table 3), but there was no significant difference between the mid and high molasses fed animals slaughtered on day 86 (Table 3). Final carcass pH was similar across treatments ranging from 5.5 to 5.6. Eye muscle area was greater for high molasses-fed heifers than for the control group (Table 3) after covariate adjustment using carcass weight. Meat colour (L*, a*, b*), initial yield, peak force and compression were similar between treatment groups slaughtered on day 65. High molasses-fed animals had a significantly higher moisture and lower intramuscular fat content than the control or mid molasses groups (Table 3).

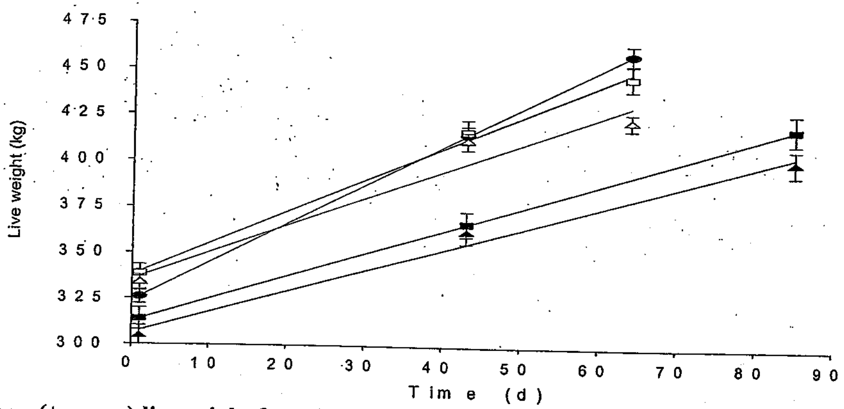

Figure 1. Mean (± s.e.m.) liveweight from induction to day 85. Lines of best fit determined by linear regression analysis are shown for; ● control; □ mid molasses to day 64; ■ mid molasses to day 85; Δ high molasses to day 64; ▲ high molasses diet to day 85. Table 2 summarises liveweight gain results.

Table 2. Productivity of Brahman crossbred heifers fed diets varying in molasses content (least squares means ± s.e.m.).

	Animals slaughtered after 64 days			Animals slaughtered after 85 days	
	Control	Mid molasses	High molasses	Mid molasses	High molasses
Number	88	45	45	36	32
Initial weight (kg)	326 ± 4	337 ± 4	333 ± 4	322 ± 5.9	310 ± 6.8
Daily gain (kg/d)[A]	2.1 ± 0.04^a	1.7 ± 0.05^b	1.3 ± 0.06^c	1.3 ± 0.07	1.2 ± 0.06
DM intake (g/kg W/d)[B]	23	23	24	26	28
Final weight (kg)[A]	464 ± 3^a	438 ± 4^b	417 ± 4^c	433 ± 5	421 ± 6

[A] Data adjusted by covariance analysis for initial weight.
[B] Intake of experimental diets from either days 13-64 or 13-85.
Means in the same row with different superscripts are significantly different (P<0.05)

Table 3. The effects of molasses feeding on carcass characteristics of Brahman cross heifers and objective and subjective measurements of meat quality of the *M. longissimus dorsi* after 64 or 85 days (least squares means ± s.e.m.).

	Animals slaughtered after 64 days			Animals slaughtered after 85 days	
	Control	Mid molasses	High molasses	Mid molasses	High molasses
Number	18	20	19	36	32
Hot carcass weight (kg)	241 ± 1.6^a	227 ± 2.4^b	215 ± 2.3^c	226 ± 3.2	213 ± 3.5
Dressing percentage	52 ± 0.2	52 ± 0.3	52 ± 0.3	52 ± 0.4^a	51 ± 0.4^b
P8 fat depth (mm)	6.9 ± 0.5^a	5.8 ± 0.5^a	4.2 ± 0.5^b	4.7 ± 0.3	5.3 ± 0.4
EMA[A] (cm^2)	65 ± 1.7^a	67 ± 1.5^{ab}	72 ± 1.6^b	65.1 ± 0.9	66.3 ± 1.0
Fat colour (subcutaneous)[B]	2.3 ± 0.2	2.6 ± 0.1	2.6 ± 0.2	2.1 ± 0.1	2.4 ± 0.2
Meat colour[C] L*	40.9 ± 0.5	40.8 ± 0.5	40.3 ± 0.5		
*a**	22.4 ± 0.4	22.8 ± 0.4	22.3 ± 0.4		
*b**	10.2 ± 0.2	10.4 ± 0.2	10.1 ± 0.2		
Peak force (kg)	4.6 ± 0.1	4.5 ± 0.1	4.4 ± 0.1		
Initial yield (kg)	3.6 ± 0.1	3.3 ± 0.1	3.4 ± 0.1		
PFIY[D] (kg)	1.0 ± 0.1	1.2 ± 0.1	1.0 ± 0.1		
Compression (kg)	1.8 ± 0.1	1.9 ± 0.1	1.9 ± 0.1		
Moisture (%)	76 ± 0.2^a	76 ± 0.1^a	77 ± 0.1^b		
Intramuscular Fat (%)	1.5 ± 0.1^a	1.4 ± 0.1^a	0.8 ± 0.1^b		
Tenderness[E]	44 ± 3.0	45 ± 2.8	47 ± 2.9		
Juiciness[E]	48 ± 2.7	54 ± 2.6	49 ± 2.6		
Flavour[E]	50 ± 2.6	54 ± 2.5	47 ± 2.6		
MQ4 score[E]	46 ±2.6	49 ± 2.5	47 ± 2.5		

[A] Eye muscle area
[B] USDA fat colour standards
[C] Minolta colour system
[D] Difference between peak force and initial yield
[E] MSA clipped data
Hot carcass weight, dressing % and EMA data adjusted by covariance analysis
Means in the same row with different superscripts are significantly different (P<0.05)

DISCUSSION

This experiment demonstrated that liveweight gains greater than 1 kg/d can be achieved when high molasses diets are fed. The results validated those previously obtained in animal house experiments when cattle fed 45-60% molasses in a complete diet gained over 1.2 kg/d, had commercially acceptable carcass traits, and provided striploins of guaranteed eating quality (Hunter 2000). In the present experiment, the liveweight gain of approximately 1.3 kg/d on the high molasses diet was likely to be an underestimate of what could have been achieved had heifers been adapted to a high molasses diet. The logistics of the commercial feedlot dictated that all heifers were adapted to cereal grain feeding. Heifers in the molasses groups encountered substantial amounts of molasses for the first time when the experimental diets were fed. Consequently, animals on the high molasses diet went through a further adaptation for up to 9 days involving reduced intakes (approximately 15.3 g/kg LW per day). Calculated metabolisable energy intakes from days 43 to 64 for heifers fed the high molasses diet and slaughtered at day 65 averaged 119 MJ/d and would be expected to have resulted in an ADG of 1.3 kg/d. However, the aberration in liveweights (Figure 1) that contributed to an underestimate of ADG for these animals could not be explained in terms of recorded feed intakes. While these animals had an ADG of less than 1.0 kg/d, medium mature size heifers weighing 400 kg could be expected to gain 1.25 kg/d with a metabolisable energy intake of 108 MJ/d (ARC 1980). There were no indications of molasses toxicity, laminitis or digestive upsets in these animals. At both slaughter times, animals were transported, held in lairage and processed as separate treatment groups. This resulted in a confounding of time of kill with carcass traits. The reduction in P8 fat depth associated with the high molasses diet in this experiment was similar to results previously reported with high molasses diets (Hunter 2000).

Results indicated that the inclusion of molasses at 29 or 50% (DM basis) in a feedlot diet has the potential to produce lean beef without affecting meat quality. This information is important at times of high grain prices, as it allows feedlot managers to formulate diets with a reduced feed cost per unit liveweight gain. High molasses diets are potentially useful for the beef feedlot industry and could be used to assure consistency of supply of cattle to the live export trade. The technology is not a replacement for conventional grain in all feedlots, but is seen as a viable strategy in northern Australia, particularly in areas close to sugar mills, and feedlots targeting premium export beef markets.

ACKNOWLEDGMENTS

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Energy sources that provide flexibility

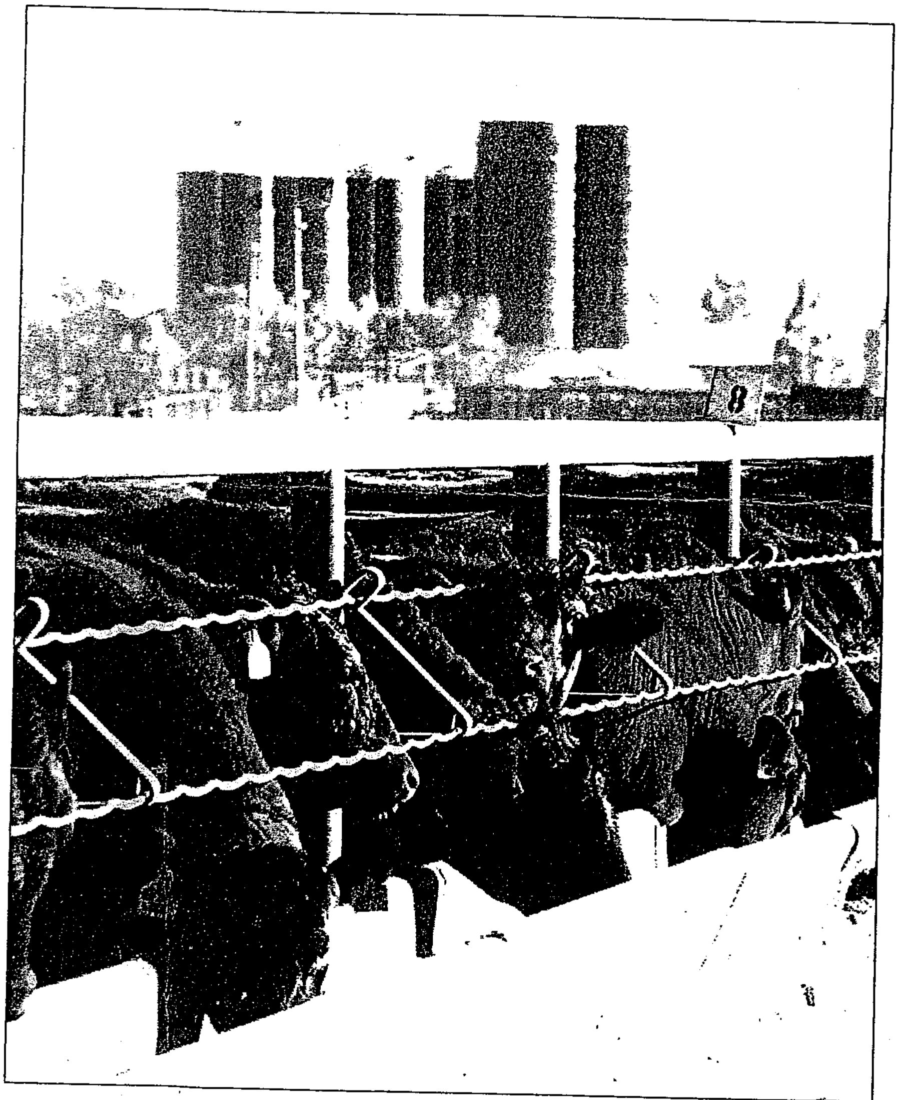
This month's Research Roundup focuses on alternatives to the use of grain as the major contributor to the energy component of feedlot rations.

THE CEREAL grains (barley, sorghum, wheat and maize) are currently the principal source of nutrient metabolisable energy (ME) for feedlot rations. Experience gained by industry during the drought of 1994/95 highlighted that supply insecurity is a core problem affecting the long-term prosperity of the Australian feedlot industry. This, combined with an identified likely increase in the real price of energy dense feedstuffs in the medium to long term, primarily driven by global supply and demand issues, prompted an assessment of a range of high-energy feedstuffs as potential alternatives to grain.

An extensive review of potential feedstuffs was undertaken and a shortlist of crops, products and by-products was prepared for more detailed assessment. Two criteria were used as the basis for this assessment: feedstuff must have a metabolisable energy (ME) equal to or greater than 10 megajoules per kilogram, and, anticipated cost must be comparable with those energy sources currently used by the Australian feedlot industry.

Three studies funded by Meat & Livestock Australia (MLA) examined the opportunities to expand the use of the following products as alternatives to grain:

- alternative energy-dense feedstuffs;
- sugarcane by-products; and,
- high ME silages.



Studies show that alternative high-energy feedstuffs can reduce industry reliance on grain as the major energy source of feedlot rations.

The studies reviewed and collated past and current research, and commercial experience, in the production and feeding of the identified products and examined the potential for existing crops, new purpose-grown crops, or the improved or expanded use of existing high-energy by-products.

While the studies did not identify any new product or by-product that would significantly protect the Australian feedlot industry against future feedstuff cost fluctuations, they did identify several products that are currently under-utilised by the industry, and offer opportunities to increase industry efficiency and provide a potential buffer against future grain price increases. Feedlot operators can use these products to reduce their reliance on feed grains as the major contributor to the energy component of rations. The products and by-products identified include:

- molasses;
- fats and oils;
- whole cottonseed;
- cassava; and,
- commercial food wastes.

Molasses

Research and industry experience indicate that molasses (11.0 MJ/kg DM) can be beneficially incorporated in balanced production rations at rates much higher than that generally practised in Australia. A 15% inclusion rate is feasible and there are indications that rates of 25% or higher are possible and practical.

Further research is currently being conducted to investigate these possibilities.

Fats and oils are high-energy feedstuffs (35 MJ/kg DM) whose cost frequently makes them an attractive ration component and source of ME. When included in rations at 2% to 6% of ration dry matter, they have been shown to enhance ration quality and livestock performance. To utilise fats and oils effectively, feedlot operators need a reliable supply of quality product, the infrastructure to handle them in bulk, and a quality control program to ensure product integrity.

A further MLA funded study has collated all the relevant information to support the use of fats and oils in feedlot operations.

Whole cottonseed (WCS) is a palatable high-energy feed (14.5 MJ/kg DM) with high protein levels (23% crude protein CP). The feedlot industry uses 80,000 – 100,000 tonnes of WCS annually. Its broader use within the industry is constrained by the perception that it can affect carcase quality (hard fat), and that the maximum advisable ration inclusion levels are in the order of 8% to 12%. Research indicates there is potential to include WCS at levels up to 20%.

Further research is being planned to investigate the use of WCS.

Cassava is a potentially useful source of ME (12.7 MJ/kg DM) in feedlot rations, able to replace up to 30% of DM in growing and finishing rations. However, it is low in protein (3.1% CP), something that needs to be taken into consideration when formulating rations.

A protocol for the import of cassava from Thailand has been established, but there have been no imports to date. An MLA funded study has shown that there is potential to establish a commercial cassava production and processing industry in the Northern Territory.

Commercial food wastes

Potential exists to identify the available food industry waste resources, which may support in part a strategically located and localised industry. There is currently no real knowledge of what, where, when and how much is available, or of its nature, supply and consistency pattern. The high moisture content of many of the processing wastes makes transport expensive.

The studies show there is a range of alternative high-energy feedstuffs available to feedlot operators, which can reduce industry reliance on grain as the major energy source of feedlot rations. Reports are available from MLA for operators wanting further information on utilising any of these alternative feedstuffs.

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Molasses a sweet option for the north

Molasses has been traditionally viewed in the northern cattle industry as a useful feed for survival feeding and as a vehicle for delivering protein and mineral supplements.

But recent research is helping 'redefine' molasses as a palatable, high-energy feed which has the potential to form the basis of production feeding diets for cattle.

Some 1.2 million tonnes of molasses are produced annually as a by-product of the Australian sugar industry - mostly along the Queensland coast, but also in northern New South Wales and the Ord River area of Western Australia.

About two-thirds of this is currently sold offshore, primarily to the US.

Just 150,000 tonnes are used annually within the Australian livestock industry, where demand is erratic.

Dr Bob Hunter, a scientist with CSIRO Tropical Agriculture in Rockhampton, is leading industry funded research - through Meat and Livestock Australia's North Australia Program - looking into the greater use of molasses in diets for various types of feeder cattle produced by the Australian beef industry.

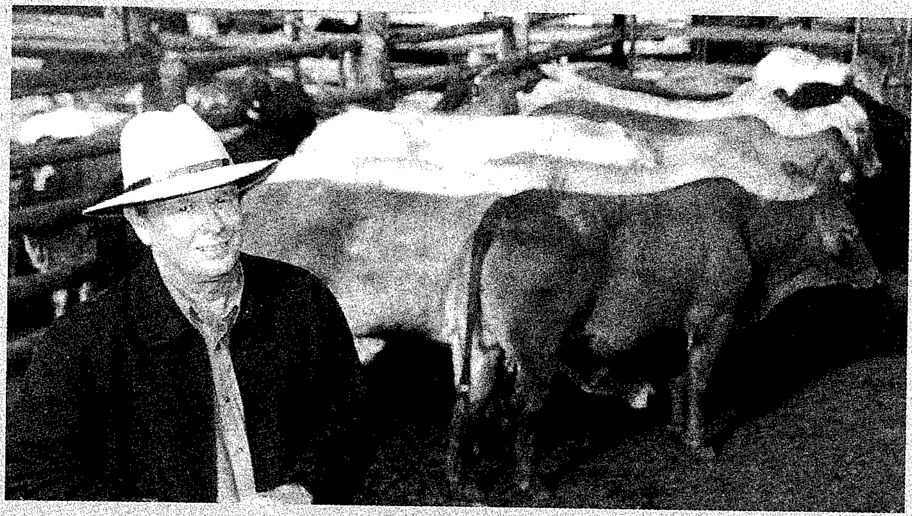
Prior to this work, conventional wisdom suggested toxicity was likely when molasses was fed for extended periods above 20% of total ration and only modest growth rates were achieved in trials.

But Dr Hunter and his team set about developing better balanced molasses-based rations, applying basic nutritional principles in incorporating urea as a source of crude protein, lipids, minerals and roughage.

Results have been encouraging.

Under pen conditions up to 150 days, diet formulations ranging from 30% to 72.5% molasses (dry matter basis) were trialled using Brahman steers.

Weight gains of up to 1.6 kilograms a day were achieved, conversion rates were within acceptable ranges and there was no evidence of molasses toxicity.



Dr Bob Hunter's research suggests cattle diets high in molasses could underpin an intensive cattle finishing industry in north Australia or parts of Asia.

More recent work has focused on the impact on carcase quality of high molasses diets.

No residues have been found and meat quality criteria, including fat and meat colour, pH and fat cover, were no different to the carcases of cattle fed conventional rations.

Carcases from trial animals were also subjected to Meat Standards Australia taste panel testing and rated equivalent to similar cattle fed on a conventional grain-based feedlot diet.

Having established that high levels of molasses can be fed successfully using the new balanced rations without affecting meat quality, attention is now turning to the application of the technology, through research jointly funded with Livecorp.

The first step, to be carried out over the next six months, is validation under commercial conditions.

The early stages of this work will focus on three key aspects:

- Lotfeeding in Australia in areas with access to molasses, supplying conventional export and domestic beef markets. Cattle in many areas of northern Australia struggle to produce liveweight gains of more than 120kg/year. But used as an example, if 500,000 tonnes of molasses was available annually to provide 50% of the diet of intensively fed cattle, 100kg of liveweight could be added to 1.3 million northern cattle.
- Depot feeding for the live export trade - allowing cattle to be 'stockpiled' for export during periods when shipment is difficult because of seasonal conditions. This would help improve supply chain management into live export markets. This work will also look at the technology's application in South East Asian feedlots, with the aim of providing our customers there with greater flexibility in ration design and costing.
- Another opportunity - but one that requires more detailed investigation - is intensive supplementation of cattle in paddock situations. One confounding factor in this that must be examined is substitution, where there is a tendency, particularly on better quality pasture, for animals to simply replace the pasture resource with (more expensive) molasses intake. Strategies to counter this are being considered.

The molasses feeding research has been strongly supported in kind by commodity suppliers Mackay Sugar, Fibretek and Cargill.

MORE INFO?

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Sweet solution investigated

By PETER HENDERSON

RESEARCH on cattle carried out by CSIRO researchers based at the Rendel Laboratory in Rockhampton, Queensland, showed high molasses diets could have economic and productivity benefits for feedlot and pasture cattle.

In feedlot situations, molasses can replace part of the grain component.

Early trials showed that when fed diets containing up to 60pc molasses, cattle could produce weight gains of up to 1.6kg per day.

Cattle fed diets with 29pc and 50pc molasses in a commercial feedlot also had similar carcase and meat quality characteristics to grain-fed animals including colour, pH, fat content, tenderness and overall consumer acceptance.

The cattle on 29pc and 50pc molasses had liveweight gains of 1.7kg/day and 1.3kg/day respectively compared to 2.1kg/day for grain-fed controls.

The benefits of molasses would depend on the relative price of grain.

High molasses diets are potentially useful for the feedlot industry and could be used to assure consistent supply to premium beef markets.

Research leader Bob Hunter said the CSIRO team was also researching the use of molasses to increase growth rates of cattle at pasture in northern Australia during the dry season.

High molasses inputs could help overcome weight loss in cattle to produce more marketable animals at a younger age.

However, the rapid intake of sugar in the molasses, when freely available, can cause digestive disturbance due to the high concentration of soluble sugars and potassium in molasses and through rapid acid production caused by sugar fermentation in cattle rumens.

The major concern was the decline in intake and digestibility of the pasture grasses caused as a byproduct of the adaptation of the microbes in the rumen to handle large inputs of molasses.

This effect could vary with changes in nutritive value of the pasture grasses, and reduce the liveweight gains.

The researchers investigated these problems in a series of animal house trials, in which cattle were offered forage plus molasses in varying amounts, with urea and phosphorus also supplied, but no extra supplemental protein.

Generally, as molasses intakes increased, grass intake and digestibility was decreased.

The decline in grass intake per unit of molasses eaten was greater for a medium quality forage than when a poor quality forage was offered at the same time as molasses.

However, no difference between the two grasses was seen when molasses was offered alone, followed by grass alone.

Maximum liveweight gains were about 1 kg per day. To improve these gains, supplements which provide additional protein for absorption in the small intestine are needed.

The CSIRO team is extending its work to monitor behaviour of grazing animals when given a choice between molasses and grazing at pasture.

One aim is to strategically place the molasses troughs in order to force cattle to walk between troughs and water sources, with the expectation that patch overgrazing could be eliminated. Research in this area is continuing.

Feed alternative

Molasses sweetens diet for lotfed steers

CSIRO Livestock Industries researcher Bob Hunter explains why molasses has the potential to form the basis of a high-energy ration for feedlot cattle, particularly in northern Australia.

Photos: CSIRO Livestock Industries

New CSIRO research shows feedlot cattle fed diets high in molasses will achieve liveweight gains of up to 1.6 kilograms per day and feed conversion efficiencies comparable with traditional grain feedlot diets.

Cattle supplied with diets high in molasses can achieve liveweight gains of up to 1.6 kilograms per day, acceptable in traditional grain-based feedlot diets, according to new CSIRO research.

Traditionally molasses has been viewed as a useful survival feed, a low-grade energy supplement and a carrier for the delivery of protein and mineral supplements.

But CSIRO Livestock Industries research suggests there are both economic and liveweight benefits if high levels of molasses are incorporated in diets used for intensively finishing cattle.

Molasses is a palatable energy-dense feedstuff providing 11 megajoules of metabolisable energy per kilogram of dry matter (DM).

Previous research in the Caribbean during the 1970s has shown cattle fed diets of about 90 per cent molasses achieved weight gains of about 0.7 kilograms per day.

Potential benefits would be further increased if high molasses levels were incorporated into traditional feedlot diets.

Market demand

Markets for the northern Australian beef industry are changing. Exports of manufacturing beef to the United States are fluctuating while there is increasing demand for quality beef products from Asian markets.

To provide a reliable supply of product to these markets throughout the year, a period of intensive feeding of cattle for rapid weight gain may be necessary.

Queensland sugar mills produce more than one million tonnes of molasses annually. About 600,000t of this supply is exported and 150,000t is used for feeding livestock.

Molasses is usually cheaper than grain per unit of metabolisable energy, especially in tropical areas.

CSIRO scientists have calculated if 500,000t of molasses were available annually and represented 50% of the diet of intensively fed cattle, it would be possible to add 100kg of liveweight to about 1.3 million head. This gain could be pivotal to continuing the supply of northern cattle and beef into Asian markets.

Feed trial

To study the potential benefits of a molasses-based diet, CSIRO conducted a trial at its Rendel Laboratory at Rockhampton, Queensland, during 1999, with funding support from Meat and Livestock Australia.

A group of 32 high-grade Brahman steers was divided into four groups and fed one of four diets — 30%, 45%, 60% or 72.5% molasses (dry matter basis).

The diets were formulated to contain 14% crude protein per kg DM and comprised molasses, whole cotton seed at 20% of DM, cotton seed meal, 1.5% urea, Fibremax (alkali treated bagasse) and 1.5% mineral mix. The steers were implanted with a growth promotant Compudose 100 on day one of the growth experiment and day 80.

The steers were fed the experimental diet ad lib for 175 days. Feed intake and growth rate were measured during the final 140 days.

TABLE 1 Productivity and eating quality of steers fed molasses-based diets

Diet formulations	30% molasses	45% molasses	60% molasses	72.5% molasses
Dry matter intake (grams per kilogram of liveweight gain per day)	24	24	23	16
Liveweight gain (kilograms per day)	1.3	1.5	1.6	1.3
Feed conversion efficiency (kg of dry matter intake per kilograms of liveweight gain)	8.3	7.2	6.5	5.5
Final liveweight (kg)	494	523	537	498
Carcass weight (kg)	261	282	287	256
Dressing percentage	53	53	53	52
P8 fat depth (millimetres)	5	15	12	11
Eye muscle area (centimetres squared)	68	72	71	63
Tenderness	46	61	51	51
Juiciness	50	58	53	54
Flavour	51	55	54	50
Overall acceptance	50	58	53	47

Source: CSIRO Livestock Industries.

in brief

CSIRO

- CSIRO research shows a molasses-based diet for intensively finished steers can achieve liveweight gains of up to 1.6 kilograms per day, similar to liveweight gains achieved in traditional grain-fed feedlots.
- A consumer panel found the steaks from steers on high molasses diets of acceptable eating quality.
- An economic analysis also shows a molasses-based finishing diet can increase herd gross margin by up to 9.5 per cent when compared with a grass-fed finishing system.

At the end of the project, the steers were slaughtered and the eating quality of the striploin — including tenderness, juiciness and flavour — was assessed by a Meat Standards Australia consumer panel.

Increased growth rate

Each molasses diet formulation achieved liveweight gains ranging from 1.3–1.6kg/day and feed conversion efficiencies acceptable in traditional feedlot diets (see Table 1).

There were no indications of molasses toxicity, laminitis or digestive upsets in any animal.

The consumer panel also found the steaks of acceptable eating quality.

The 45% molasses group achieved a Meat Quality score of 57 which compared favourably with the score of 56, recorded for Meat Quality Co-operative Research Centre Brahman steers of similar liveweight finished on a grain-based diet in a feedlot.

This study shows commercially attractive liveweight gains and acceptable eating quality can be achieved in northern Australia with high molasses diets.

Southern Australian cattle may also achieve similar liveweight gains with a high molasses diet. But it may not be as economically attractive compared with northern cattle producers, due to cheaper molasses prices in Queensland.

Economic analysis

CSIRO researchers also carried out an economic evaluation of molasses feeding using the Breedcow-Dynama computer software package.

A base herd of 2500 adult cattle was used to evaluate economically the intensive molasses-based finishing system. This herd produced grass-fed steers of 3–4 years of age.

The herd parameters used for the modelling activity included a low weaning rate of 55% and an average female mortality rate of 4%.

Non-pregnant heifers were culled after mating in the 2–3 (40%) and 3–4 (25%) year old age groups as is industry practice. Operating costs for the herd were derived from industry estimates.

A pasture only production system using 3–4-year-old grass-fed steers was used as the base for comparision with the 60% molasses ration finishing system. The system used 18–20-month-old steers achieving a daily weight gain of either 1.3kg/d or 1.5kg/d. An average feeding period of 120 days was used.

A consumer panel found the steaks from steers fed high molasses diets are of acceptable eating quality.

The molasses-based finishing system was intended to turn off younger steers in the last quarter of the year when there is a price premium associated with a shortage of finished cattle.

Improved gross margin

Depending on molasses price and daily gain, the high molasses finishing regime increased herd gross margin by up to 9.5% when compared with the base grass-fed steer system (see Table 2).

The improvement in daily gain from 1.3–1.5kg/d in the 120 day finishing system improved herd gross margin by at least 2.7%.

The improvement in herd gross margin using intensive molasses-based feeding is attributed to the movement of increased numbers of sale stock to more premium (younger and higher price/kg of carcass weight) markets and the higher overall turnover. Female sales contributed similarly to sales receipts in each system.

Herd structure

There were herd structural changes associated with the change in finishing system and a younger turn-off.

A 20% increase in joined female numbers was required in the move from a three- to four-year-old pasture finishing system to the two-year-old turn-off molasses finishing system.

Although the total adult numbers remained at 2500, total numbers carried in the two-year-old system were reduced by only 1.5%. This was because of increased female numbers and steers subjected to intensive finishing were only removed from pasture for three months before transport from the property to slaughter.

The radical reduction of up to two years in turn-off age has significant implications for overall herd dynamics. An adjustment period may be needed, particularly to build up female numbers, before the turn-off age can be permanently reduced to two-year-old.

The development of molasses finishing systems could result in substantial increase in domestic demand for molasses. The likely impact on price has not been investigated in this analysis.

Recently molasses has been available at mills for $45–$60/t. Using an average price of $50/t at mill and transport costs of $2.70 per kilometre (single semi-trailer tanker) it was calculated 480km was the maximum distance from a sugar mill that molasses could be landed at less than $100/t. Larger capacity (B double) tankers could increase the range to about 550km.

The analysis represented a worst case scenario where no premiums were paid for younger cattle of assured eating quality.

In addition a lower than expected (1.3kg/d) finishing liveweight performance was used, increasing the required feeding period.

But given these worst case assumptions, the system can still generate similar or higher business returns at molasses prices up to $120/t compared with a grass-fed finishing system producing older steers.

TABLE 2 Herd gross margins using an intensive molasses finishing system

Molasses (dollars per tonne)	Herd gross margin ($) (1.3 kilograms per day)	Herd gross margin ($) (1.5 kilograms per day)	Herd gross margin ($) (1.5 kilograms per day)
Grass-fed base herd	$294,729	$294,729	$294,729
Feeding period (days)	120	120	102
$50	$313,713	$322,716	$322,057
$90	$301,509	$309,987	$311,682
$100	$298,458	$306,848	$309,089
$120	$292,355	$300,438	$303,901
$150	$283,202	$290,893	$296,122

Source: CSIRO Livestock Industries.

Further research

Commercial testing of the molasses-based diet will start during 2000–01, supported by Meat and Livestock Australia and Livecorp.

The diet will be tested in two feedlot environments, aiming to prove the commercial attractiveness of molasses in terms of cattle growth, carcass and meat quality and economics.

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