THE EFFECT OF RATION ON WASTE MANAGEMENT AND ODOUR CONTROL IN FEEDLOTS

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SUMMARY

Public pressure to prevent pollution of the environment is increasing. Cattle feedlots probably could partly achieve this by adopting a waste minimisation strategy that either reduces the quantity of waste produced or it's pollution potential. This may be achieved through dietary manipulation.

We conducted a cattle feeding trial and associated odour measurement experiment to determine if dietary manipulation can reduce odour generation without restricting cattle performance. We analysed the chemical and physical properties of faeces produced by cattle fed six different rations: dry-rolled sorghum, dry-rolled sorghum + Actigest®, dry-rolled sorghum + Hoechst® product, steam-flaked sorghum, dry-rolled barley and steam-flaked barley. Animal performance was also monitored. We found that the chemical, physical and biological characteristics of manure, the main waste product of feedlots, can be modified by changing the ration. Simulated feedlot pads were prepared using the faeces collected from the cattle in the feeding trial. Odours sampled from pads prepared using faeces from cattle fed sorghum-based rations had a significantly higher intensity than those from barley-based rations.

Further, the potential for water pollution may be reduced by having less nitrogen, phosphorus, salt and volatile solids in the manure. We collected sixteen feed ration samples and analysed them to determine their phosphorus content. All of the rations exceeded the recommended phosphorus requirement for Jap-ox cattle and most exceeded the recommended requirement for local-trade cattle. Reducing the amount of phosphorus and other nutrients in manure may be important where the area available for waste utilisation is limited.

Thus, intensive livestock's enterprises that have particular environmental concerns may be able to reduce them through ration modification. Waste minimisation to reduce odour generation or excess nutrients may be possible whenever producers have a choice of ration types, as most Australian lot feeders do. However, waste minimisation can be widely adopted only after nutritionists recognise that animal performance is not the only criterion by which ration suitability should be assessed.

INTRODUCTION

Wastes generated by cattle feedlots and other intensive livestock industries may pollute the environment through odour nuisance and by contaminating water resources with excess nutrients. Public awareness of environmental issues has increased pressure for livestock industries to improve their environmental performance. This has resulted in regulatory agencies requiring environmental impact assessments for proposed feedlots and the use of environmental management plans for existing facilities.

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ENVIRONMENTAL ISSUES WITH CATTLE FEEDLOTS

The environmental issues facing the lot feeding industry have recently been reviewed (Watts 1992). The two major issues for the industry are odour nuisance and pollution of surface and underground water resources.

Feedlot odour generation

It is not yet known which properties of manure most influence the intensity of odour generated at feedlots but it is known that the most offensive odours are released during anaerobic fermentation.

Anaerobic fermentation is affected by pH. This influences which species of microflora are active (Hashimoto et al. 1981, Parkin and Owen 1986). Anaerobic bacteria from the rumen and hindgut may ferment organic materials such as undigested cellulosic and starchy materials and dead bacterial cells in faeces to volatile fatty acids (VFA's) and the sulphurous compounds. Butyric and valeric acids, a host of minor longer chain length acids, and the sulphurous compounds are regarded as particularly unpleasant odours. The microorganisms primarily responsible for these odours in feedlot situations are yet to be identified, although it is probable that they originate from the animals endemic microflora. As odours appear to be less pronounced when animals are fed certain diets, it may become possible to reduce odours by dietary manipulation. This will alter the characteristics of the manure, such as pH, and consequently certain bacterial populations in the manure that produce the odours may be less competitive and abundant.

Mineral content of manure may also influence the anaerobic fermentation process and related odour generation. Sodium, potassium, calcium, magnesium, iron, copper, chromium, nickel, zinc and sulphides stimulate anaerobic fermentation at low concentrations but are toxic to microorganisms at high concentrations (Hashimoto et al. 1981, Parkin and Owen 1986). The concentration of particular minerals in manure may therefore influence production of offensive odours during the fermentation process.

Australian feedlot managers believe that undigested starch in manure acts as a food source for microorganisms and is therefore the most important determinant of odour generation. Some managers also suspect that more intense odours are generated when cattle are fed dry-rolled sorghum rations rather than barley or steam-flaked sorghum rations (Tucker et al. 1991).

If faecal pH, mineral content or starch content can be shown to influence odour, feedlots with a history of odour complaints probably could reduce odour generation by dietary manipulation.

Water pollution by feedlots

To reduce the potential for water pollution, nitrogen, phosphorus and salt concentration and volatile solids content (VS) of manure should be reduced. (Volatile solids content is the proportion of 105°C oven dry total solids that is driven off as volatile combustible gas after heating to 550°C for three hours. This is equivalent to the organic matter content of a sample.) This is the main emphasis of a waste reduction strategy for pigs proposed by Jongbloed and Lenis (1992).

Currently pollution of water courses due to excess phosphorus is of particular concern in Australia following recent outbreaks of blue-green algae. Although we have examined the effect of different rations on the phosphorus content of manure in this paper, the ideas outlined are equally applicable to the management of other nutrients and

Careful management of nutrients within the feedlot system should prevent don of water resources.

Waste minimisation at cattle feedlots

A viable waste minimisation program reduces either the total quantity of waste or ›ollution potential of the waste. Traditionally, research into livestock environmental :s has centred on management of wastes rather than waste reduction. However, there strong trend in other environmental research to move away from waste management into source reduction. The major waste-product of feedlots is manure. The physical, ogical and chemical characteristics of manure can be altered by varying the ıposition of the feed ration (Taiganides and Hazen 1966, Frecks and Gilbertson 1974, gbloed and Lenis 1992). In a review of the Australian feedlot industry, Tucker et al. ›1) found that most feedlot rations are based on sorghum or barley which are both dily and economically available in the major lot-feeding areas. While most feedlot :rators process their grain either by dry-rolling or hammer-milling, some large nmercial feedlots are steam-flaking or reconstituting. A knowledge of the effect of ion type on manure characteristics is the first step in planning a waste minimisation ogram.

Waste minimisation for odour control

To investigate the potential for odour reduction through waste minimisation we Inducted an animal feeding trial and associated odour measurement trial. We analysed ıeces produced by cattle fed six different rations to determine the differences in physical nd chemical properties. The faeces were later used in odour generation studies. We ound that ration type significantly influenced some chemical and physical characteristics ıf faeces. Ration type also affected odour generation. Hence, waste minimisation for ›dour reduction through ration modification could be an option at feedlots.

MATERIALS AND METHODS

Animals, diets and measurements

Thirty-six Hereford steers with a mean, shrunk, starting liveweight of 315 kg were housed in individual stalls. The cattle were assigned to one of six ration treatments using a randomised block design with liveweight as the blocking factor.

The cattle were fed Rhodes grass (*Chloris gayana*) hay for their first seven days in the stalls. They were introduced to high grain rations over a two week period to allow their digestive systems to adapt to the change from a high roughage diet. Groups of six Hereford steers were each fed one of the following feedlot rations: dry-rolled sorghum, dry-rolled sorghum plus Actigest®, dry-rolled sorghum plus Hoechst® product, steam-flaked sorghum, dry-rolled barley and steam-flaked barley.

Feed intake, Iiveweight gain, feed conversion efficiency, dry-matter digestibility (DMD) and carcass characteristics were measured. Dry matter digestibility (DMD) was measured in vivo.

The rations consisted of grain (82.4%), Rhodes grass hay (5.0%), cottonseed meal (4.1%), molasses (3.0%), bentonite (2.2%), limestone (1.4%) and mineral premix (1.9%). Urea was added to make rations iso-nitrogenous. A Hoechst® product and Actigest® additive were added according to manufacturers' recommendations. These additives are claimed to be odour suppressants and could therefore be considered as part of a waste minimisation program. Cattle were fed twice daily. Residue feed material left in troughs was removed prior to feeding.

Faeces collection and chemical analvsis

Faeces were collected over two seven-day periods, each including half the cattle from each treatment. The first collection began after the cattle had been fed the high-grain ration for 28 days. The second began 28 days later. Faeces were collected in bags harnessed to each animal. The bags were changed morning and evening. Each day, the two collections from each animal were weighed, then thoroughly mixed using a commercial cake mixer to remove diurnal variations in the faeces. Two sub-samples (10% w/w) were taken from each animal daily, one for daily dry matter determination and the other for freezing and later analyses of starch and ash content, and pH. Large quantities of faeces were frozen for later use in the study of odour generation from simulated feedlot pads. It was not possible to collect and analyse the urine. Hence, the data presented in the results are for faeces alone and may not fully represent manure (that contains both urine and faeces).

On completion of both collection periods, stored faeces for each animal were defrosted, bulked, mixed and sub-sampled (10% w/w). Starch, ash, volatile solids content, dry matter content and pH were determined. Starch content was determined after extraction and hydrolysis of the starch to liberate the glucose from the sample (Faichney and White 1983). Ash and volatile solids content were determined by ashing samples at 550°C for three hours. The pH of samples was determined using a Beckman 3500 pH meter (Faichney and White 1983).

Preparation of simulated feedlot pads

Three simulated feedlot pads were prepared for each of the six ration types. Although the pads were outside, a 24 m x 7 m ‘rain-out’ shelter protected them from rainfall. The shelter allowed complete control over the moisture content of the pads during their preparation and testing.

The pads were designed to represent feedlot pens stocked by 450 kg cattle at a density of 10 m^2/hd. They were prepared in open-bottomed trays, 0.25 m wide, 1 m long and 200 mm deep. These were laid out in two parallel rows that fitted under the 'rain-out' shelter. The position of each tray in the rows was randomly selected.

The trays were set into the ground with the top of each tray flush with the ground surface. About 50 mm of heavy black clay was compacted into the bottom of each tray forming an impermeable seal. A layer of interface material removed from a commercial feedlot was placed over the clay and moulded to the sides of the trays to seal them. About 6 kg of defrosted faeces from the cattle feeding trial were initially spread over the interface layer. Thereafter defrosted faeces were added weekly at a rate of about 3 kg of faeces/ tray/ week. Urine was collected from a local abattoir and applied to the pads at a rate of 750 mL/week. Twice a week the pads were stamped fifty times with a 100 mm x 100 mm hard-wood ‘hoof’ to simulate the action of cattle movement. This process continued for about six weeks before the trays were considered representative of a commercial feedlot and thus ready for odour testing.

Odour sampling and measurement system

A portable, open-bottomed wind tunnel was used to sample the odours from each ay. The wind tunnel fitted neatly over each tray. Odours were sampled from the down-ind edge of the tray. Air was drawn through a charcoal filter before passing over the ay and then through a fan. A bulk wind speed of 1 m/s through the wind tunnel was sed for all odour sampling.

Odours were collected in 120 L mylar bags. The sample bags were filled using a ung' arrangement with the bag contained in a rigid drum. By pressurising the drum, the ample bag could be evacuated. The sample bag could then be filled by evacuating the lrum. It took about 30 seconds to fill a bag. Measurement of odour samples from the trays commenced within about 15 minutes of sampling. Odour concentration was determined using the three-port, eight-panellist, forced-choice, dynamic-dilution olfactometer built by the Queensland Department of Primary Industries (QDPI) and described by Jones et al. (1993). Odour concentrations were calculated immediately following each test. Odour concentration is expressed as standard odour units (SOU) where an odour unit is 'that quantity of a gaseous substance which, distributed in odour-free air, is distinguished by half a panel of observers from odour-free air' (Dutch Normalisation Institute 1990).

Experimental procedure for odour measurement and data analysis

On the first day of the odour sampling period, the pads were relatively dry (surface moisture content of about 20% w.b.).

Odour sampling then commenced. This involved placing the wind tunnel over a tray; starting the fan; adjusting the wind speed to 1 m/s; waiting about five minutes for the system to stabilise; and then taking an odour sample. Tunnel wind speed, air temperature, humidity and pad temperature were recorded for each odour sample. A sample of surface manure was collected so the pad moisture content at the time of each odour measurement could be determined. Since it took a full day to test all 18 trays, we measured each complete replicate of six trays as a group.

On completion of the measurement of odour concentrations of pads, the pads were examined. The structure of the pads was similar to a commercial feedlot with a layer of loose manure over a hard, compacted interface layer.

That afternoon, water equivalent to 20 mm of rainfall was added to each tray. The hard-wood 'hoof' was used to thoroughly mix the water into the manure profile. On the following morning, the standard 750 mL of urine was applied. Odours emitted from the pad were sampled over the next three days using the same method as for the dry pads. The only difference in experimental procedure was that the trays were stamped fifteen times before placement of the wind tunnel to simulate cattle movement. This was necessary to prevent formation of a dry surface crust over the pad that would inhibit odour release.

Analysis of variance on odour concentration was undertaken to test the effects of factors. The analysis of variance contained an embedded factorial of two grain types and two processing methods; as well as the effect of time after wetting. A generalised linear model was then fitted to the odour concentration to remove the effects of the above design factors and to test dependence on the continuous variables of pad temperature, air temperature, relative humidity and time of day.

RESULTS OF FEEDING EXPERIMENT

Cattle fed the dry-rolled sorghum rations produced faeces containing over five times the starch content of the other treatments that had similar starch contents ($P<0.01$). Faecal starch content was similar for the three dry-rolled sorghum treatments (Table 1).

Production of wet faeces was not influenced by ration type. However, cattle fed the three dry-rolled sorghum rations produced greater quantities of dry faeces (relative to liveweight) than cattle fed the remaining rations ($P<0.05$) and had the highest faecal dry matter contents ($P<0.05$). This suggests that the dry-rolled sorghum rations were less digestible than the remaining rations.

The ash content of faeces produced by cattle fed barley and steam-flaked sorghum rations was similar and greater than the ash content of the three dry-rolled sorghum treatments ($P<0.01$) which were not different.

Cattle fed the barley and steam-flaked sorghum rations produced faeces with a similar volatile solids content that was lower than for cattle in the dry-rolled sorghum treatments. The faecal pH values for cattle fed either of the barley rations were similar and significantly higher than those of the cattle fed sorghum ($P<0.01$). The pH of faeces from cattle fed the steam-flaked sorghum ration was also higher than that of the faeces collected from cattle fed the dry-rolled sorghum rations ($P<0.05$) (Table 1).

All cattle fed dry-rolled sorghum had similar intakes of feed and tended to eat more than cattle fed the steam-flaked sorghum and barley. Cattle fed dry-rolled barley had lower rates of liveweight gain and had higher feed conversion ratios than those fed steam-flaked barley. Otherwise, animal performance, including carcass characteristics, was not influenced by ration type.

TABLE 1 Starch, ash, volatile solids and ph of faeces collected from steers fed six feedlot rations

	Starch Content (%)	Ash Content (%)	Volatile Solids/ Liveweight (kg/1000 kg)	pH
Dry-rolled sorghum	24.63	14.23	7.35	4.96
Dry-rolled sorghum + Actigest®	22.03	14.52	6.76	5.10
Dry-rolled sorghum + Hoechst®	22.77	14.58	6.21	5.13
Steam-flaked sorghum	2.37	18.48	4.84	5.58
Dry-rolled barley	4.07	18.83	4.79	6.38
Steam-flaked barley	2.53	19.67	5.09	6.22
Least Significant Difference	7.61*	1.85*	1.73*	0.31*
	9.91**	2.53**	2.37**	0.47**

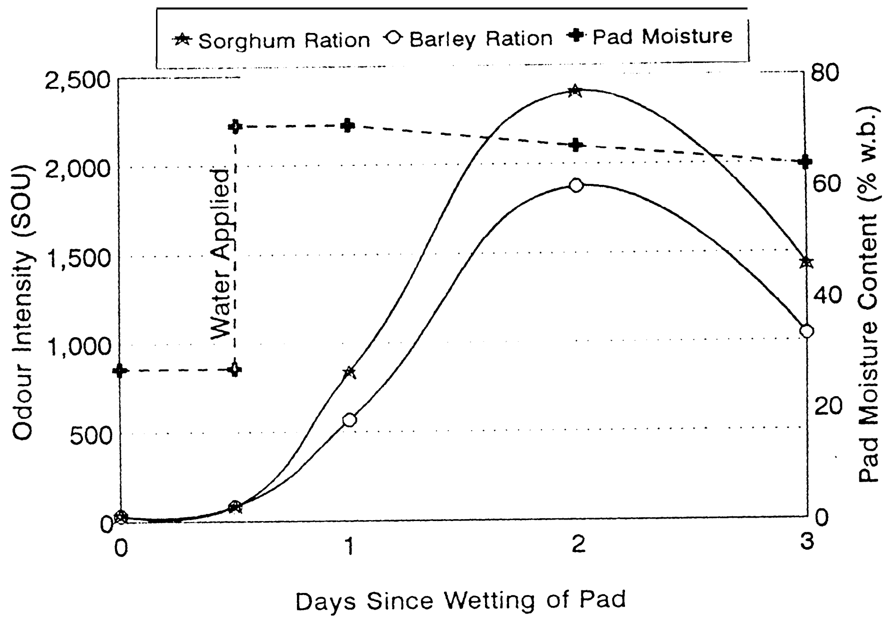
* $p<0.05$ ** $p<0.01$

RESULTS OF ODOUR EXPERIMENTS

Time since-wetting was the dominant influence on odour concentration. Figure 1 shows the pattern of odour generation following wetting of the pads. The dry,, undisturbed pads emitted very little odour. Odour concentration rose significantly on the first day after wetting ($P<0.05$). On the second day after wetting, odour concentration peaked at a concentration roughly three times higher than on the previous day ($P<0.05$).

: concentration declined on the third day after wetting to be significantly lower than : previous day (P<0.05) although it was still higher than on the first day after wetting)5) (LSD = 252.504).

Figure 1 shows the variation in pad moisture content over time (averaged over all . Since there was a close association between pad moisture content and time after ng it was not possible to separate differences in odour generation between pad ture contents without considering the time after wetting effect.



gure 1 **Effect of ration type on odour generation**

Sorghum-based pads produced significantly more odour than barley-based pads '<0.05). The mean value for odour emitted from sorghum pads was 1197 SOU and from ie barley pads 892 SOU (LSD = 296). Grain processing method did not significantly ffect odour generation.

There was a marked diurnal variation in the surface temperature of the pads. For the ry pads, the surface temperature typically was 11°C for the first sample in the morning 08:30) rising to a maximum of up to 30°C at 14:00 and then declining to about 24°C for he last sample in the afternoon (16:OO). For the wet pads, the early morning temperature vas similar to the dry pads. However, the maximum surface temperatures peaked at only 20°C declining to 17°C for the last sampling in the afternoon. Ambient air temperatures were recorded as each odour sample was collected. Over the duration of the trial these ranged from 11.7°C to 30.5°C.

When the effect of pad temperature was fitted to the generalised linear model, it was found that there was a significant increase in the concentration of odour emitted from the pads as pad temperature increased (P<0.05).

DISCUSSION OF ANIMAL AND ODOUR EXPERIMENTS

Cattle fed dry-rolled sorghum rations had higher faecal starch contents and lower faecal pH values than cattle fed the other rations. We think that starch content, pH and mineral composition of manure may be important determinants of odour generation in cattle feedlots. The differences we observed in these parameters between faeces from cattle fed the three dry-rolled sorghum rations and the remaining rations suggested that odour generation from these two groups of faeces could differ. Because starch content and pH both varied with ration type in our study, we can draw no conclusions about which factor had the major influence on odour generation. If a high faecal starch content or low faecal pH promotes malodour production, then feeding barley or steam-flaked sorghum rations may form part of a waste minimisation program for odour control. The trend of our odour measurements is that faeces from cattle fed barley rations produced less odour than that from sorghum rations. This supports the belief of the feedlot managers.

Our results for faecal pH are consistent with those of Kellems et al. (1979) who found that cattle fed sorghum grain produced faeces with a lower pH than barley ($P<0.05$). Their research indicated that pH influenced release of basic volatile nitrogenous gases and associated odour generation.

In this trial, the Actigest® and Hoechst® additives had no significant influence on any of the measured characteristics of manure. Kellems et al. (1979) also found that additives, such as sagebrush, did not reduce the offensiveness of odour from cattle wastes, although they found that peppermint oil did. Calcium bentonite may also have an effect (Sweeten et al. 1977).

The response of odour over time and the magnitude of the odour concentrations measured using simulated feedlot pads were similar to those described by Watts et al. (1993) for a commercial feedlot. Odour concentration peaked about 48 hours after significant wetting of the pads. The peak odour concentration was about 68 times higher than the odours from dry pads that is also similar to the results of Watts et al. (1993) who found a ratio of about 60. Time since wetting was the most important factor influencing the concentration of odour released from the pads. There was no relationship between the concentration of odours emitted from the pad and pad moisture content *per se.*

The peak in odour concentration on the second day after wetting fits the hypothesis proposed by Watts et al. (1993). Odour concentration from dry feedlot pads is low and it appears this is due to low bacterial activity due to a lack of moisture. It is hypothesised that upon wetting, bacterial metabolism and growth accelerates. Initially, aerobic bacteria would proliferate and rapidly utilise the oxygen in the pad leading to anaerobic conditions. The anaerobic bacteria, that survive the dry periods in a moist, anaerobic layer at the base of the pad can now proliferate and the level of odours rise. The anaerobic organisms ferment substrates such as undigested plant material and dead microbes to form VFA's and sulphurous compounds, some of which are regarded as unpleasant odours. After a couple of days, the pad may have dried out and overall bacteria activity declined. Also, as the pad dries, a crust forms over the surface limiting emissions of odours from layers deeper in the pad. In summary, the hypothesis is that, after significant wetting of the pad, there would be strong odours emitted because of anaerobic fermentation of wastes and the odours would decline as the pad dried. The data collected in this experiment fit this hypothesis.

The data show that the sorghum-based rations resulted in more odour than the barley-based rations. Unfortunately, it is not possible to establish which characteristic of the faeces from these rations was responsible for the difference. The faeces differed significantly in pH, starch content and volatile solids content. Any of these factors, and possibly others, may have caused this difference. Although steam flaking significantly reduced the starch content and volatile solids content of the faeces from the sorghum-based rations, it did not affect odour generation. Starches vary in how readily fermentable they are. Although the total amount of starch remaining in the faeces of the cattle fed the dry-rolled ration was high, the quantity of readily fermentable starch might only have been similar to that contained in the faeces of the cattle fed the steam-flaked sorghum ration.

The increase in odour concentration in response to increased pad temperatures could ıer be due to a physical process (increased volatilisation of gases) or a microbiological ɔcess (increased bacterial activity). Mesophilic anaerobic bacteria grow best at about ʾC and are inactive at 10°C. Therefore, the diurnal variation in pad temperatures may ıse a similar variation in bacterial activity with associated odour generation.

Since ration type influenced dry faeces production (as a proportion of liveweight), ɘding barley or steam-flaked sorghum rations can be part of a waste minimisation ɾategy because they reduce the total quantity of faeces for disposal.

WASTE MINIMISATION FOR NUTRIENT MANAGEMENT

To examine the potential for nutrient management by waste minimisation we ıeasured the phosphorus content of commercial feedlot rations and compared this to ecommended requirements. We then examined the environmental consequences of ·xcess phosphorus in the ration. We found many feedlot rations had phosphorus contents n excess of minimum requirements. When rations contain excess phosphorus,, ıignificantly more waste utilisation area may be required depending on soil type and :ropping program. Feeding rations that closely match animal requirements could help prevent watercourse pollution due to excess nutrients. Nutritionists should aim to meet animal requirements for this mineral but not supply excess.

Recommended phosphorus content of rations

The phosphorus requirements of cattle vary according to liveweight and performance level. The NRC's recommendations for minimum phosphorus intakes are given in grams per head per day for cattle of differing liveweights and performance levels (NRC 1984). Assuming average dry matter intakes we have calculated that the recommended phosphorus content of the ration should be 0.26% for local-trade cattle and 0.18% for Jap-ox cattle. This is shown on Figure 2.

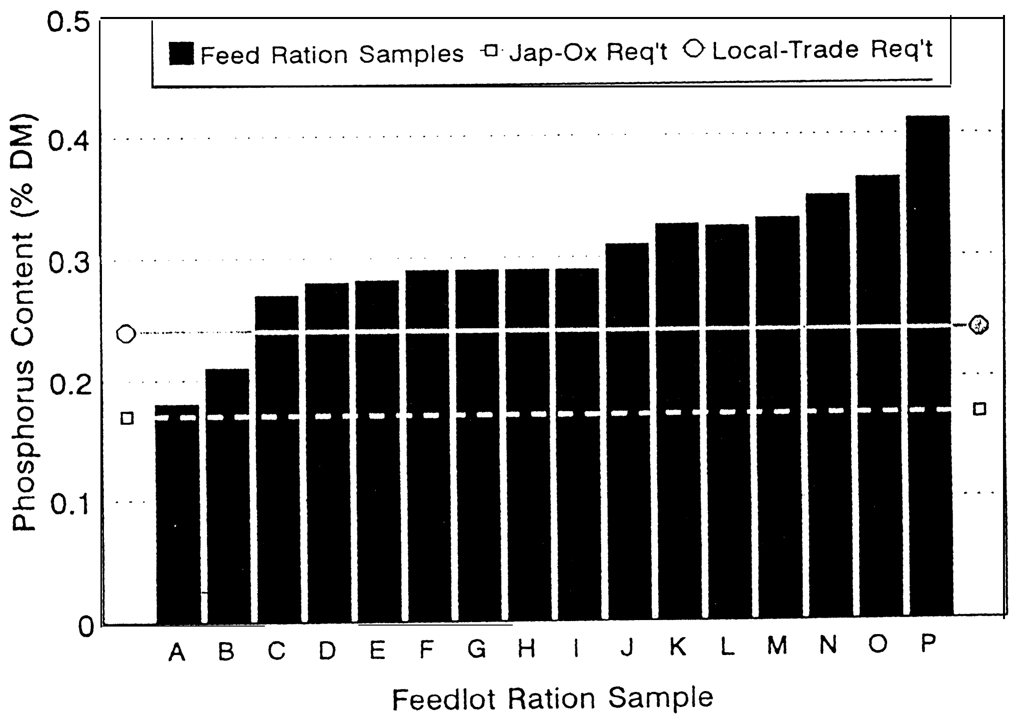


Figure 2 Variation in phosphorus content of feedlot ration samples

Actual phosphorus content of rations

We analysed sixteen samples of feedlot rations, six collected from the feeding trial described above and ten taken from feed troughs at commercial feedlots (see Fig 2). All rations exceeded the minimum NRC requirement for Jap-ox cattle and all but two exceeded the requirement for local-trade cattle. In some cases there may have been over twice the NRC recommendations if the rations were being fed to Jap-ox cattle.

Environmental consequences of excess phosphorus

The objective of waste utilisation programs at feedlots is to sustainably use the nutrients in manure on waste utilisation areas as part of a cropping system. The amount of phosphorus excreted by the cattle determines, in part, the area of land required as an utilisation area.

Excess phosphorus consumed in feed is excreted. A 570 kg beast would consume about 13.7 kg DM/d. If the phosphorus content of the ration was 0.26% then the animal would consume 35.7 g P/d. For a liveweight gain of 1.2 kg/day, 24 g P/hd/d is the minimum recommended intake. Thus, the ration would be supplying 11.7 g P/d in excess of recommended requirements. Only 10 g P/d would be retained due to liveweight gain (8 g P/kg of liveweight gain) and thus 25.7 g P/d would be excreted. However, if the phosphorus content of the ration was 0.4% and assuming the same liveweight gain and phosphorus retention, then the ration is supplying 54 g P/d. With 10 g P/d retained, 44 g P/d would be excreted. Thus, the phosphorus output in manure would be 1.7 times higher for this ration.

To illustrate the effect of this on waste management, Watts et al. (1992) developed a phosphorus mass-balance model of a complete feedlot system. This simple model uses cattle performance parameters for the feedlot and the phosphorus content of the ration to predict the annual mass of P produced in manure. This phosphorus must be disposed of on land utilisation areas. Phosphorus can be removed from these areas as crop harvest or can accumulate in the soil profile as largely unavailable phosphorus compounds. The sustainable life of a feedlot land utilisation area can be defined as the number of years taken to saturate the soil profile with this unavailable phosphorus. The time taken for this to happen depends on the manure loading rate, the soil phosphorus absorption characteristics and the crop's phosphorus removal rate. Table 2 shows the effect that different phosphorus contents in rations could have on the area of land required for waste utilisation for different scenarios. The many assumptions needed to develop Table 2 are given in Watts et al. (1992).

The availability of sufficient land for waste utilisation is an important issue for some feedlots. This is particularly true where soils have low phosphorus absorption capacities.. Table 2 shows that the land area required for sustainable development can increase substantially if there is a large amount of phosphorus for disposal. By adopting a waste minimisation strategy for nutrient management, some feedlots probably could increase in size without adverse environmental consequences or even operate where they may not otherwise be permitted.

le 2 Effect of P content in ration on land utilisation area required. (10,000 head capacity)

rket	Local-Trade (315 kg)		Jap-Ox (570 kg)	
eding Period	90 days		200 days	
Content of Ration	0.26%	0.4%	0.26%	0.4%
in Manure (t P/yr)	23	51	86	149
rop and Soil	Land area (ha) required for 50 year sustainable life			
rigated Maize and Red lay Loam	80	190	325	570
ryland Winter Grain nd Vertisol Soil	925	2150	3670	6440

Alternative rations

Sorghum and barley grains typically have a phosphorus content of about 0.34% and 1.38% respectively while well-eared corn silage has a phosphorus content of 0.22% (NRC 1984). By partly replacing grain with silage, the phosphorus content of the ration can be formulated to more closely match recommended requirements rather than exceeding them. Similarly the phosphorus content of cottonseed meal (solvent extracted) is 1.21% while peanut meal (mechanically extracted) has a phosphorus content of only 0.61% (NRC 1984). Therefore it is possible to select a protein meal or other ration ingredients that are comparatively low in phosphorus. Alternative rations can be formulated that produce similar levels of animal performance but are lower in phosphorus content.

Review of minimum requirements

It is possible to formulate rations in which the phosphorus content is kept at the minimum recommended level. However, perhaps the minimum phosphorus requirements listed in nutrient requirements tables require review.

Underwood (1981) claims that there is increasing evidence that commonly used recommendations for phosphorus intake requirements for growing beef cattle are too high. Coates and Ternouth (1992) agree that the recommended requirements listed in the ARC (1980) are too high for cattle grazing north Australian tropical pastures. They believe that there is a need to reassess the requirements in terms of absorption efficiency, endogenous losses and requirements for production. The phosphorus requirement is calculated using the factorial technique (ARC 1965 and 1980) as the sum of phosphorus utilisation by the cattle divided by the absorption coefficient. A conservative co-efficient of absorption is used to allow a safety factor for complications (Ternouth 1990).

In a recent review of their standards, the Australian Standing Committee on Agriculture (ASCA) used a coefficient of absorption of 0.7 for phosphorus (Ternouth 1990). The ARC (1980) uses a more conservative co-efficient of absorption of 0.58 while the NRC (1984) uses a true digestibility value of 0.85.

ASCA use a value of 20 mg/kg liveweight to estimate endogenous faecal losses. This value was derived from a range of 12-26 mg/kg liveweight or a net requirement of 3.6-7.8 g/day (3.6 g/day being the minimum net loss) (ARC 1965 cited by Ternouth 1990). ARC (1980) also assumes a minimum endogenous loss of 12 mg/kg body weight per day for weaned cattle. The NRC (1984) uses a value for maintenance of 2.8 g of retained phosphorus per 100 kg of liveweight gain. An allowance of 8 g phosphorus per kg of liveweight gain must be added to the ASCA requirements (Ternouth 1990).

DISCUSSION

To date, cattle performance has been the only criterion by which rations have been assessed. With increasing pressure to protect the environment, the effect of ration type on waste characteristics should also be a criterion for ration evaluation (Jongbloed and Lenis 1992).

Producers are likely to readily accept recommendations for ration changes that help minimise waste if they do not limit performance or profitability. Van Horn (1991) showed that the nitrogen and phosphorus excreted by lactating dairy cattle could be significantly reduced by changing feed rations without limiting performance. In our trial we found that ration type had very little influence on cattle performance. However, Plasto (1990, pers. comm.) found that cattle fed a dry-rolled barley ration were 15% more efficient than cattle fed dry-rolled sorghum ration. Cattle fed a steam-flaked barley ration had a similar performance level to those fed a dry-rolled barley ration. However cattle fed a steam-flaked sorghum ration had a feed conversion efficiency about 18% better than those fed dry-rolled sorghum. Cattle in all treatments had similar rates of liveweight gain. The improved efficiency of cattle fed barley rations and steam-flaked sorghum rations was due to a lower feed intake.

The main obstacles to waste reduction practices are concerns over increased production costs or reduced productivity. Most Australian lot feeders can economically feed either sorghum or barley grain. Large feedlots can also afford to install steam-flaking or reconstitution processing plants. Lot feeders usually have a choice of roughage types and commercial mineral premixes, and can also use rumen modifiers, bentonite, sodium bicarbonate and some other additives if they wish. Thus, they have the flexibility to be able to adopt a waste minimisation strategy.

CONCLUSION

The results of our study suggest that scope exists for Australian lot feeders to adopt a waste minimisation program through judicious selection of ration ingredients. Further research into the influence of ration type on specific manure properties is needed so that waste minimisation can be adopted by intensive livestock industries as a viable part of their environmental management program.

Chemical, physical and biological characteristics of faeces can be beneficially modified through ration modification.

Where an intensive livestock enterprise has a particular environmental concern, such as odour nuisance or excessive nutrient production, alteration of the ration may be an option for reducing that concern. But before waste minimisation can be widely adopted, nutritionists must challenge the paradigm that animal performance is the only criterion by which ration suitability should be assessed.

ACKNOWLEDGMENTS

We extend appreciation to Mr Bob Dillon and Mr John Connell for their assistance in conducting the trial, Dr Athol Klieve for his contribution to our understanding of the microbiological processes and to Mrs Alison Kelly for the statistical analysis of the data.

The assistance of the Meat Research Corporation of Australia in providing the funding for this research is gratefully acknowledged.

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