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PROTEIN ENRICHMENT OF CEREAL GRAINS FOR LIVESTOCK

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Every year Western Australian farmers feed about 750,000 tonnes of cereal grain to livestock, mostly to sheep but also to dairy and beef cattle. These grains are fed as drought feeds, as supplements to augment poor quality or scarce paddock feed or in growth rations to attain higher levels of production. Many grains fed, however, have a low protein content and are therefore used inefficiently by animals.

Several methods of improving the low protein content of feed grains have been tested. They include the addition of lupin seed, spraying oats with urea and gassing oats with ammonia.

Protein needs of sheep

Sheep diets should contain at least 15 per cent crude protein for pregnant or lactating ewes and growing weaners; about 12 per cent for growing adults and about 8 per cent for survival or maintenance of dry animals.

Given the normally low protein content of dry pastures and stubbles, and the variable protein content of cereal grains grown here, sheep diets will often contain lower than optimum levels of protein for growth, pregnancy or lactation of animals, even though sheep are known to selectively eat the better parts of the available dry feed.

The protein content of oats, for example, can vary, depending on the variety, where it was grown, soil type and rainfall. In a trial at Wongan Hills Research Station in 1981, the growth rate of weaners ranged from 30 grams per head per day when fed oats containing 8 per cent crude protein to about 140 g per head per day when oats of 16 per cent crude protein content were fed.

These results indicate the advantage of testing cereal grains for their crude protein content if the grain is to be fed for growth, such as in weaners. If the tests indicate low levels of crude protein, then remedial action is necessary.

Several methods of improving the crude protein content of cereal grain rations fed to livestock have been investigated.

Lupin seed

Lupin seed contains 30 per cent crude protein and can be added to an oats ration to improve the protein content being fed to sheep. The benefits from adding various levels of lupins were tested in trials from 1978 to 1981. Growth rates of weaner, hogget and adult sheep on dry pastures and in feedlots were recorded. Reports of much of this work (funded by the then Australian Meat Research Committee) can be found in Department of Agriculture Bulletin No. 4071—Finishing sheep to produce meat and Farmnote No. 6/86—Finishing sheep for live export.

The research confirmed the reliability of lupins as a high protein source for mixing with oats. Many farmers are using this method.
Lupin seed can sometimes be in short supply, relatively expensive or undesirably contaminated with weed seeds, so that other methods of enriching the protein content of diets based on cereal grains were studied.

Urea dissolved in water can be sprayed onto oat grain to raise the ration's crude protein content, as the addition of 1 per cent urea (w/w) to oats raises crude protein analyses by about 3 percentage points.

Urea is a simple nitrogenous compound available in granulated form for use as a fertiliser. It has long been realised that, given a source of energy in the diet, micro-organisms in the sheep's rumen can use sources of simple nitrogen such as urea to manufacture protein. This 'microbial protein' can be used by the sheep for its own protein needs.

The Department of Agriculture recommends that four parts granulated urea and one part granulated sulphate of ammonia (a source of sulphur) are dissolved in water and sprayed from a knapsack onto oat grain as it tumbles in a mixer or before it enters an auger. The grain must be thoroughly mixed with the urea mixture to avoid palatability or toxicity problems in sheep. A maximum of 12 kilograms (1.2 per cent) of urea and 3 kg of sulphate of ammonia dissolved in 15 to 20 litres of water should be used per tonne of grain. Sulphur should be added because it is an essential nutrient for rumen microbes and animal tissues.

In a trial at Wongan Hills Research Station in 1983, the growth rates of weaner sheep fed unrestricted amounts of whole grain oats with a standard vitamin and mineral premix for 100 days were compared with those fed urea-treated oats. Results are shown in Figure 1.

Sheep fed untreated oats showed large variations in growth rates, with a marked drop in performance as the oats' protein content fell from 13 to 10 to 7 per cent. Adding urea to boost the protein content to either 13 or 15 per cent made little difference to oats already containing 10 per cent or more crude protein. Growth rates increased significantly when low protein oats (7 per cent crude protein) were boosted to 13 per cent, with further boosting to 15 per cent making little difference.

These results indicate that weaners grow faster when they are fed oats containing at least 10 per cent crude protein than when they are fed lower protein oats (7 per cent) boosted to the same level with urea.

A possible explanation for this is that young sheep need a lot of protein which can be met only partly by microbial synthesis of urea-nitrogen into protein in the rumen. Extra sources of plant protein appear to be needed for optimum growth. This is probably why the use of urea in growth diets for young sheep is only partially successful, but nevertheless often worthwhile.
Urea-treated oats for pregnant ewes

Research by the Victorian Department of Agriculture in 1979, using Merino ewes mated to Border Leicester rams, showed that using a urea spray to boost oats of 7.2 per cent crude protein to 12 per cent produced marked responses in ewe live weights and lamb growth rates.

Ewes fed at less than maintenance levels for six weeks after mating lost an average of 8 kg live weight. Eight weeks before lambing they were penned and fed various oat-based diets. Urea-treated oats were fed at a rate calculated to provide 1.5 times the maintenance requirement, followed by unrestricted feeding for the first four weeks of lactation. Ewes and lambs were then put on irrigated pasture.

Ewes fed urea-treated oats were nearly 6 kg heavier than ewes on untreated oats on the first day after lambing, and about 11 kg heavier four weeks later. At lambing, lambs from ewes fed urea-treated oats were not significantly heavier than lambs from ewes on untreated oats, but they were more than 6 kg heavier at four weeks of age. This difference still remained at five months.

Ammonia

Anhydrous ammonia has long been used in treating feedstuffs to improve their nutritive values, particularly to improve the digestibility of low quality roughages. The Western Australian Department of Agriculture has studied the effects of feeding cereal grains treated with ammonia on growth rates of sheep.

Ammonia is a colourless gas which dissolves readily in water and contains 82 per cent nitrogen. When mixed into feedstuffs, the gaseous ammonia dissolves in the moisture in the feed, forming ammonium hydroxide. This product reacts with the fibrous husks, breaking down the lignin-hemicellulose bonds and thus increasing digestibility of fibrous feeds.

Laboratory tests in 1983 showed that ammonia at a rate of 1.5 per cent of the weight of oats could be added to a silo of oats without causing a pressure build-up problem in the silo. The time allowed for the oats to absorb the ammonia ranged from 24 hours to two weeks. Although the reaction had proceeded satisfactorily within 24 hours, the longer the reaction time, the less free ammonia was lost. Only small quantities of ammonia were lost from oats treated for longer than a week when stored in the open for three days.

After the technique had been shown to work in the laboratory, large silos of grain were treated with ammonia and the grain was fed to sheep to assess its acceptability and the effects on production.

As much as 1.2 per cent ammonia by weight was added to 10 and 35 tonne silos of oats. After two weeks, the ammonia had penetrated the silo's contents, but there was some variation in the distribution of ammonia throughout the silo. When samples were taken, the grain was found to be very hot (estimated at 60°C) because of the chemical reaction, and it was still warm several weeks later. Although this should not pose a problem, previously heated grain might reduce the digestion and solubility of protein in the rumen. This could increase the efficiency of protein use in the sheep through the by-pass protein effect. This by-pass protein effect is beneficial because protein which is not degraded in the rumen can be digested elsewhere in the sheep's gut and used by the animal.

By adding as much as 1.2 per cent ammonia by weight, the crude protein content of an oats diet can be increased by as much as 6 per cent. Adding another 2 per cent water to the grain allows more ammonia to be added and crude protein content can be increased by as much as 10 per cent.

Badgingarra trials

Further research into the use of ammonia was carried out at Badgingarra Research Station in 1983. Two sources of non-protein nitrogen—ammonia gas and urea—were added to an oat grain ration to produce four levels of crude protein.

The oats were treated in 4 500 litre galvanised steel household water tanks, modified to make them air-tight and fitted with augers. After gassing, the tanks were left for two weeks before the oats were fed. Treated and untreated feeds were given indoors to pens of Merino ewe weaners. The sheep were gradually introduced to the diets with decreasing quantities of hay over 14 days, and were then fed unrestricted amounts of oats every second day for eight weeks. Their voluntary feed intakes and growth rates were compared.

Sheep ate more as the crude protein content increased and there was no difference between their daily feed intake of ammonia-treated and urea-treated oats.

There were marked differences, however, between the growth rates of weaners fed urea-treated oats compared to those fed
ammonia-treated oats (Figure 2). Daily growth rates of ewe weaners fed urea-treated oats increased when fed as much as 14 per cent crude protein and then levelled off, probably because the sheep could not use any more urea.

The daily growth rates of weaners did not level off when they were fed ammonia-treated oats. Growth rates increased steadily, virtually in a straight line, up to the highest level of 15.5 per cent crude protein.

Vasse trials

The effect of increased crude protein content was investigated further at Vasse Research Station in 1986. As much as 2 per cent ammonia was added to oats, equivalent to an additional 10 per cent crude protein, and the rations fed to weaners. Over the range from 10 to 20 per cent protein, feed consumption and weaner growth rates increased with increasing crude protein content, while the feed conversion ratio declined. Although no roughage was added to these diets, few digestive problems developed. At the highest levels of added ammonia (2 per cent) feed consumption approached 800 g per head per day, growth rates 160 g per head per day and feed conversion ratios were as low as 5 to 1.

Barley has also been successfully treated with ammonia. However, it absorbs less gas and reacts less readily than oats. Research into ammonia-treated barley fed to cattle and sheep will be completed this year.

Fittings and safety information

Anhydrous ammonia is stored in vessels made of mild steel which do not corrode. It does however react with copper, aluminium, zinc, tin and alloys of these metals including brass.

The corrosion of galvanized silos is therefore a problem, but the Government Chemical Laboratories have indicated that several paints are available which will protect silos. The preferred types are 'high build, acrylic emulsion paint' used in sealing silos for fumigation against insects. Other protectants under investigation include fish oil based paints.

New modular fibreglass silos are an alternative to coating existing galvanized silos.

Brass waterpipe fittings and reinforced vulcanized rubber hoses were used in our trials. Some corrosion has been seen, and nylon ball valves and stainless steel gas fittings seem best.

Anhydrous ammonia can cause severe burns to human and animal skin and is particularly dangerous to the eyes, nasal passages and moist area of skin. Chemical safety goggles, overalls, rubber shoes and gloves should be worn at all times. If handling ammonia in enclosed areas, a canister-type respirator is essential.

Costs of ammonia and urea treatments

Although anhydrous ammonia is a more costly source of nitrogen than urea—$1.30 per kg nitrogen compared to 65c per kg nitrogen—it is easier to use and produces a more effective diet for sheep growth. When urea or lupins are added to oats they must be mixed and handled twice, whereas ammonia can be applied through a hose and by turning on a gas tap. The gas also kills insects in the grain and most weed seeds are sterilised. The cost (January 1986) of treating a tonne of grain at the recommended rate of 12 kg anhydrous ammonia per tonne is $13.40.

The table, which is a ready reckoner, shows the proportions of lupins, urea or ammonia needed for oat rations of various crude protein contents.

Further reading


Acknowledgement

CSBP and Farmers Ltd., contributed to the funding of the research reported in this article.