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FEEDING UREA TO CATTLE

By D. J. BARKER, Beef Research Officer, Animal Division

RUMINANTS normally obtain the protein they require by digestion of the organisms that inhabit the forestomach (rumen), not by direct digestion of the dietary protein they chew up and swallow. The organisms break down the dietary protein and then rebuild proteins in the form of more organisms.

However, these organisms can also utilise some substances which are not proteins, for the production of their own protein. In order to achieve this they must of course have access to those elements from which proteins are built up, and these include nitrogen. One of the sources of nitrogen which is suitable for this purpose is urea.

The simplified diagram below illustrates the two systems.

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In practice, even on “normal” diets, cattle pass some urea into the rumen, via the saliva, and this is also available for the building up of some microbial protein.

This urea originates as a breakdown product of bodily protein, some passing to the saliva from the blood-stream, and much being excreted in the urine. Other forms of non-protein nitrogen present in pasture, etc., are also utilised by the rumen organisms in the same way.

All proteins contain nitrogen, and feeding stuffs are most simply and crudely evaluated as a source of protein by estimating the amount of nitrogen they contain.

Since proteins contain approximately 16 per cent. nitrogen the crude protein content of a feeding-stuff is .25 times its nitrogen content. “Crude protein content” is not really an accurate term—what is really meant is that the foodstuff contains as much nitrogen as is contained in 6.25 times its nitrogen level of crude protein.

Farm feeding stuffs vary widely in “crude protein content” and various types of cattle vary in their need for protein. Cows in high lactation and very young calves need the highest proportions of protein in their diets and dry, mature animals require the lowest.

Under some conditions it may thus be necessary to supply supplementary protein to certain classes of cattle.

Most sources of supplementary protein are relatively expensive compared to sources of energy, and this has caused farmers and research workers to search for cheaper sources of protein or other suitable forms of nitrogen. The Table below shows some comparative costs of crude protein (or nitrogen level x 6.25) in various feeds when used as sources of protein only:
<table>
<thead>
<tr>
<th>Feed Material</th>
<th>Price per 100 lb.</th>
<th>Nitrogen content x 6.25 (&quot;crude protein&quot; content)</th>
<th>Price per 100 lb. &quot;crude protein&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal grain (barley)</td>
<td>$2.00</td>
<td>9%</td>
<td>$22.00</td>
</tr>
<tr>
<td>Hay—good quality legume</td>
<td>$1.50</td>
<td>18%</td>
<td>$ 8.33</td>
</tr>
<tr>
<td>Linseed meal</td>
<td>$4.50</td>
<td>35%</td>
<td>$16.67</td>
</tr>
<tr>
<td>Meat meal</td>
<td>$5.00</td>
<td>50%</td>
<td>$10.00</td>
</tr>
<tr>
<td>Urea</td>
<td>$3.00</td>
<td>290%</td>
<td>$ 1.04</td>
</tr>
</tbody>
</table>

However, all these feeding stuffs, except urea, contain a good deal of energy as well as protein. If the diet already contains sufficient energy, the extra energy supplied in these feeds will be wasted, unless some of the dietary energy can be replaced by that in the supplement economically.

Most ruminants, except the younger ones or heavily lactating breeders, tend to have an adequate proportion of protein in their diets when fed the usual farm feeds such as pasture, cereals and hay.

However, some feeds may not contain a sufficiently high proportion of digestible energy for production of finished carcases. Also the total amounts of digestible energy and protein in some farm feeds such as poor quality roughages may be insufficient for production, owing to their high content of relatively indigestible fibre. Such feeds will not support high rates of production because they cannot be consumed in sufficient quantity to supply the nutrients required. Supplying extra nitrogen as protein or non-protein nitrogen can increase the rate of consumption to a level sufficient for a level of production better than that which would be achieved by poor quality roughages alone.

In the case of non-protein nitrogen supplements such as urea, this will only occur in the presence of a supply of energy in a form suitable for rapid utilisation by the rumen organisms, and there is evidence that starchy feeds (such as grains) are more suitable than sugars (such as in molasses) for this purpose.

Utilisation of the nitrogen in urea is also affected by a number of other factors. These are, firstly, the length of time for which urea is fed—the organisms of the rumen, or perhaps the ruminant animals themselves, improve in efficiency of utilisation of urea nitrogen the longer they consume it.

Secondly, the proportion of total nitrogen in the diet—above a certain level the more nitrogen present in the diet, the poorer the utilisation of nitrogen becomes. Present indications are that about 1 per cent. nitrogen in a diet which is about 70 per cent. digestible is enough for the maintenance of fully developed ruminants, but higher percentages are required in young growing animals which are laying on flesh and in heavily milking cows which are excreting a relatively high proportion of protein in milk.

Thirdly, the proportion of dietary nitrogen supplied as urea—the higher the proportion supplied as urea, the poorer the utilisation of the nitrogen becomes, in spite of the fact that the rumen organisms can manufacture all the amino-acids necessary from non-protein nitrogen sources if sufficient energy and trace-elements are present. Animals have in fact been maintained and have grown on such feeds for long periods of time, but their performance is improved by the inclusion in the diet of some of the higher quality proteins containing some of the essential amino-acids.

The present recommendation is that not more than one third of the dietary protein nitrogen should be replaced by urea, and that a nitrogen: sulphur ratio of 10 : 1 should be used in the diet.

From the foregoing information we can begin to sort out when protein supplements in general, and urea in particular, are likely to be of use to the farmer:

**Protein supplements in general will be useful when:**

(i) The diet otherwise available is adequate with regard to energy, etc., but is deficient in protein for the type of animal and the purpose for which it is to be fed (survival, maintenance, production of milk or meat), or,

(ii) A diet otherwise cheap and readily available is deficient in both energy and protein for the purpose required and it is possible to get better consumption and utilisation of the readily available feed by supplying both protein and energy supplements in limited amounts.
Urea supplements in particular will be useful when:

(i) The conditions governing the usefulness of protein supplements in general apply (above).

(ii) An adequate supply of energy is readily available, preferably in the form of starches.

The actual amount of digestible energy supplied in this form will depend upon the relative costs of various forms of energy available. All the digestible energy of the diet should be supplied in this form to obtain maximum nitrogen utilisation, but economic considerations may dictate that much of the animal’s energy requirement is met by other sources of energy such as cellulosics (as in roughages). Thus, to ensure that an animal utilises a given amount of nitrogen, it will probably be necessary to vary the proportion of nitrogen with varying proportions of roughages in the diet.

(iii) An adequate supply of minerals and trace elements, particularly phosphorus, sulphur and cobalt, is made available.

(iv) Two thirds of the dietary protein is available from other sources, preferably containing high quality protein.

(v) The costs of supplying urea plus accessory energy, trace elements, and so on to the diet do not result in a total ration cost higher than that of available alternative rations which will achieve the same results.

Bearing the above points very much in mind, a number of ways of feeding urea to cattle are available if it should be considered necessary and desirable.

Maintenance and survival of dry stock

The following common farm feeding stuffs contain suitable proportions of available energy and protein for maintenance of dry cattle over nine months of age:

- Dry legume-based annual pasture residues.
- Cereal grains.
- Pasture hay.
- Good cereal hay.

Poor quality cereal hays and straws are the only other feed likely to be available in drought in any quantity. Of these, wheat straw contains a large proportion of indigestible material, and oaten and barley straw and poor quality hays will probably contain an inadequate proportion of nitrogen and energy.

Thus the usefulness of proteins and urea as a supplement to drought rations for dry stock will probably be confined to occasions when products such as these are forming the greater proportion of the drought ration.

However, readily available energy (as in grains) should also be included in the ration, so the feeding policy should be to use a ration containing roughly half the animal’s energy and protein requirement in the form of grain and half in the form of roughage plus urea. If the roughage contains 35 per cent. digestible energy and 0.6 per cent. nitrogen, and the grain contains 75 per cent. digestible energy and 1.4 per cent. nitrogen, in order to make up a diet in which the nitrogen content is 1.4 per cent. of the digestible energy, we could use:

4 lb. grain, supplying 3 lb. energy + 0.056 lb. nitrogen + 12 lb. roughage, supplying 4 lb. energy + 0.072 lb. nitrogen.

to make a mixture supplying 7 lb. digestible energy + 0.128 lb. nitrogen. That is, in which the nitrogen content is nearly 2 per cent. of the digestible energy content.

However, owing to the high proportion of energy supplied as cellulosics and the lower digestibility of the ration, a higher percentage of nitrogen in the diet is likely to be necessary to make use of a sufficient amount of nitrogen for maintenance purposes. It is to rations such as these that responses to urea are most likely to be obtained, for example, by adding 0.05 lb. of nitrogen (roughly 1½ oz. urea) to the above mixture.

The precise quantities of nitrogen necessary with varying proportions of cellulosics and starches in the diet have not been defined, and thus only a rough guide can be given.

Production stock

In young growing animals, the maintenance of a satisfactory metabolic state almost inevitably involves some growth, as developmental processes are occurring at a relatively high rate during this phase.
From birth onwards the preferential growth of the major tissues of the body is in the order—skeleton, musculature, fat. The protein content of the diet necessary to support this growth is highest at birth and lowest at the fattening stage, when it is similar to that required for maintenance of dry stock.

Approximate levels at different stages of maturity are:—

- Birth to 250 lb. liveweight—17 per cent. crude protein (2.7 per cent. nitrogen).
- 250-500 lb. liveweight—14 per cent. crude protein (2.2 per cent. nitrogen).
- 500-750 lb. liveweight—11 per cent. crude protein (1.8 per cent. nitrogen).
- 750 lb.—maturity—8 per cent. crude protein (1.3 per cent. nitrogen).

(Assuming maturity at about 1,000 lb. liveweight and a diet of good digestibility).

If good quality pasture is not available to give the growth rates and finish necessary to meet a particular market, feed supplements will have to be given. In the case of animals under about 500 lb. liveweight, cereals alone will not supply an ideal balance of energy and protein. The addition of good quality legume hay to a cereal diet can give satisfactory performance, but such hay will be limited in supply. Resort will probably have to be made to the use of protein supplements.

The most readily available and cheapest of the better quality proteins is in meat meal. Using a cereal containing 1.4 per cent. nitrogen (9 per cent. crude protein) and a meat meal containing 8 per cent. nitrogen (50 per cent. crude protein), each 2 1/2 lb. of meat meal added to 100 lb. of the cereal will increase the protein content of the mixture by 1 per cent.

Urea can be used to replace up to one third of the nitrogen in the mixture, but in practice it will probably not be wise to replace more than half of that supplied in the meat meal. A mixture which could be cheaper and effective would thus contain:—

Cereal grain 100 lb., plus meat meal 1 1/2 lb., plus urea 1/2 lb. (for each 1 per cent. of extra crude protein required in the mixture.)

Such a ration, fed in reduced quantity, would also be suitable for maintaining limited growth rates in young stock instead of fattening them.

Lactating cows, if they are recently calved and in good condition, can be maintained on cereals, or cereals and hay, alone for limited periods of time. If they are in poor condition when they calve and the pasture feed position can be expected to improve in two to three months' time, it may be worthwhile feeding a better quality ration without weaning the calf.

The feed supplied should then consist of enough cereal or hay to supply the maintenance of the cow herself plus an allowance of better quality ration to support her lactation demands. This will need to be about 6 lb. of a supplement containing about 13 per cent. crude protein of good quality per 2 gallons of milk given—probably the daily consumption of many beef calves.

The type of mixture used for this supplement could be similar to that used for the young stock (above).

When using such mixtures for survival, maintenance, or production, the supply of trace elements and minerals would be supplemented by a mixture of:—

- Stock salt—25 lb.
- Finely ground limestone—25 lb.
- Plain super—50 lb.
- Copper sulphate—4 oz.
- Cobalt sulphate—1 oz.

given as a free-offer lick or mixed in the feed at about 1 1/2 per cent.

**METHODS OF SUPPLYING UREA TO CATTLE**

Probably the most important aspect of supplying urea to cattle is the care needed in introduction. The ammonia released during breakdown of the urea by the rumen organisms can be extremely toxic when absorbed into the blood stream, and this results in rapid death of the animals if they are not used to handling it.
Dry feed mixtures

When supplied in feed mixtures urea should be limited to 1/2 oz. per head per day for a few days and then increased by a similar amount every few days, until the finally desired level of intake is achieved. In practice this is most readily done by mixing the feed in the desired proportions to be used finally and supplying increasing quantities of the mixture over a two to three week period. If the stock are not used to trough feeding they should first be "schooled" by feeding a mainly roughage/grain mixture until all are feeding readily.

When roughage, grain and urea mixtures are used, they are best put through a hammer mill to improve digestibility and mixed to ensure intake of the desired proportions of each.

Snook* in 1962 suggested using Christmas Island phosphate as a limiter in feeding whole oat grain plus urea. The phosphate dust was added to grain and moistened with a urea/cobalt sulphate solution (using 3 lb. urea plus 1 oz. cobalt sulphate per 100 lb. oat grain). The quantity of phosphate dust suggested was 5-10 lb. per 100 lb. grain, the precise amount being determined by testing on stock (using no urea in the water whilst testing) to achieve a suitable level of intake.

If the intake of dry cows could be successfully limited to about 5 lb. oats per head per day by this means, the urea could be added at about 2 lb. per 100 lb. oats to provide a supplement to a ration of 12 lb. poor quality roughage per head per day for maintenance. Fed out at intervals of several days, this would save a good deal of labour and would require no crushing or hammer-milling equipment.

Urea blocks and licks

The main advantage of urea blocks and licks is the ease with which they can be supplied to stock. Commercially manufactured blocks are an expensive way of purchasing the feed ingredients that they contain but may involve little labour if no pre-mixing is required. Such blocks, whether manufactured or home-made, supply only a very small amount of readily-available energy. If used they should be put out in such way that rain cannot dissolve the urea content and leave a potentially poisonous solution lying where stock can drink it, or soften the mixture, increasing consumption to a dangerous level.

The Queensland Department of Primary Industries† reports that the following block mixture was used with good results as a supplement to low quality roughage:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crushed grain</td>
<td>40 lb.</td>
<td>80 cents</td>
</tr>
<tr>
<td>Stock salt</td>
<td>20 lb.</td>
<td>40 cents</td>
</tr>
<tr>
<td>Molasses</td>
<td>20 lb.</td>
<td>80 cents</td>
</tr>
<tr>
<td>Urea</td>
<td>10 lb.</td>
<td>30 cents</td>
</tr>
<tr>
<td>Christmas Island phosphate</td>
<td>7 lb.</td>
<td>10 cents</td>
</tr>
<tr>
<td>Meat meal</td>
<td>5 lb.</td>
<td>25 cents</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>102 lb.</td>
<td>$2.65</td>
</tr>
</tbody>
</table>

The prices quoted are W.A. (Perth) prices.

The Christmas phosphate could be replaced by plain super satisfactorily and 1/2 oz. of cobalt sulphate could be added to possible advantage. Consumption should be regulated to 1 lb. per head per day if necessary, by decreasing the grain to about 30 lb. and the molasses to 15 lb. and increasing the salt content to about 30 lb., especially during the introduction period. For maximum safety a mixture of 70 lb. crushed grain, 15 lb. molasses, 15 lb. salt and 1 gallon water can be used for introduction, and the proportions adjusted towards those above until the desired consumption level is obtained.

The block is prepared by first completely dissolving the urea in 1 gallon of hot water, adding the molasses and thoroughly mixing. Then mix the other ingredients with each other, for example in a concrete mixer, add the liquid and mix well. Put out in troughs, or part drums, tamp down firmly and leave a few hours to harden off before giving the cattle access to it.

Supplying urea in solution

Of recent years, self feeders ("lickers") have been developed, to enable solutions of urea and molasses to be dispensed in a self-regulated form, saving labour but controlling intake.

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† Cattle Husbandry Branch, Queensland, Department of Primary Industries (March 1969) "Drought Feeding of Beef Cattle", Appendix A.
The principle of the system is that a drum floats in a trough containing the liquid mixture, the cattle lick the surface of the drum, which rotates and brings up more of the mixture. The amount that is consumed by the cattle is controlled by the dilution of the mixture—the more dilute the mixture, the less urea and molasses are consumed.

The feeder

The drum floats in a trough of suitable size so that the only liquid surface exposed to the stock is that on the surface of the drum.

The Queensland Department of Primary Industries* also reports that a feeder can be made from a 44 gallon drum and a 12 gallon drum. A rectangular hole 23 in. x 20 in. is cut out of the side of the 44 nearest to the big bung hole. A cut out 2 in. wide and 1 in. deep is made in the middle of each end of the rectangular hole. Two pieces of 1 in. x ½ in. iron are welded into each cutout, extending from the cutout side of the drum to the opposite side and parallel to each other. A short piece of the iron is left projecting above the surface of the rectangular cutout and this is bored to take a ¼ in. bolt. A piece of angle-iron is welded to each end of the 44 to act as a stabilizer.

A ¾ to ½ in. axle is welded down the centre of the 12 gallon drum. This drum is put into the rectangular cutout in the 44 gallon drum with the axle between the pieces of 1 in x ½ in. iron. The bolts in the ends of these pieces stop the axle of the 12-gallon drum coming out of the tops of the guides.

Thirty gallons of solution are put in the 44 and the floating 12 gallon drum is rotated to coat the surface. The cattle do the rest.

The solution

As with all urea feeding the animals are introduced to a low concentration to begin with. A suitable mixture is prepared by using:

- 15 gallons water.
- 15 gallons molasses (approx. 214 lb.).
- 20 lb. urea.

Make sure the urea is completely dissolved, then add the solution to the molasses and mix thoroughly.

After the first day or two, adjust the water content as necessary to control the intake of the mixture to 1-½ lb./head/day.

When all the cattle have settled on to the lick and have been taking the solution at the required rate for a week or so, the urea content can be progressively increased to 45 lb. in the above mixture. 30 gallons should last 50 dry adult cattle about a week, supplying each with about 2 oz. of urea + ¼ lb. of molasses a day. Yearlings should take about ⅕ of the amount that adults take.

Minerals

Minerals can also be supplied in the licked solution in a soluble form. Phosphorus can be given as phosphoric acid (1 gallon of 85 per cent. phosphoric acid solution per 30 gallons of mixture) or monosodium phosphate (20 lb. per 30 gallons of mixture). If using phosphoric acid add the acid to the water, and not vice versa.

* Cattle Husbandry Branch, Queensland, Department of Primary Industries (March 1969) "Drought Feeding of Beef Cattle", Appendix B.
Copper could be added as 3 oz. copper sulphate per 30 gallons, and cobalt could also be included by using $\frac{1}{2}$ oz. cobalt sulphate per 30 gallons of mixture.

In order to include sufficient sulphur to balance the nitrogen: sulphur ratio of the mixture to a level of 10 : 1, it would theoretically be necessary to add 20 lb. of crystalline sodium sulphate to 30 gallons of the mixture. Whether this is necessary in practice will depend upon the availability of sulphur in the rest of the diet.

Lickers should be sited near the water point to start with. After all cattle are taking the lick satisfactorily, the lickers should be dispersed throughout the grazed area, allowing one licker per 40 to 50 head.

Sometimes difficulty may be encountered with fermentation of the mixture in the licker, resulting in loss of nutrients and reduced palatability to stock. Two possible solutions to this problem exist—either the mixture can be used up more rapidly by putting more stock on to each licker, or a certain amount of salt may be added to the solution, or a combination of these may be used. The addition of salt (up to 15 per cent. in the urea/molasses mixture) will also affect palatability, and thus the proportion of urea and molasses may also have to be adjusted to ensure an adequate intake.

This system of supplying urea to stock has gained a good deal of popularity in Queensland. It must be pointed out, however, that the costs involved are very different in W.A. Molasses is extremely cheap in Queensland, being purchased at little more than the cost of carrying it away from the sugar refineries. At $30 per drum in W.A. it is a very expensive source of energy compared with cereal grains. The main advantage of the system under W.A. conditions is the relatively low labour input required, since the animals ration themselves.

The aim of the system is to make better use of low quality dry standing roughage, of which there is usually a large quantity on the native pastures of the north. In the agricultural areas of W.A. the dry paddock legume-based residues are of better quality. The urea systems can only be useful when the legume residues are exhausted and a good supply of poor quality roughages, such as straw, is available.

**Spraying urea into straw bales**

A system that may have an application in some W.A. situations is the use of a urea/molasses/water mixture added directly to straw bales.

If the ration of straw is to be about 15 lb. per head per day, a 45 lb. bale will feed 3 animals. Dissolve 4 to 6 oz. of urea in a little water and mix thoroughly with $1\frac{1}{2}$ lb. molasses and enough water to make the solution run freely (probably about a pint). This provides enough urea and molasses to dress one 45 lb. bale of straw. Pour the solution into the cut side of the bale, using a spray or other means to ensure even dispersion. Feed out to the cattle the next day.

Use a smaller amount of urea to begin with and increase it over the course of the first two weeks. Soluble minerals and trace elements can also be added to the liquid, using a similar ratio of urea; minerals to that used in the lickers.

**Other sources of non-protein nitrogen**

A number of other products, such as buiret and various ammonium salts, have also been examined, mainly in an attempt to utilise a less toxic material than urea.

Results so far, however, indicate that while the toxicity problem can be avoided by using, e.g., buiret, the cost is higher and the utilisation of nitrogen is much poorer than using urea.
Summary

Two main points summarise the use of urea in cattle feeding at present:

- It is limited in usefulness to certain situations. For maintenance, it may be used as part of a supplement to a poor quality roughage diet. For production it may be used to supply part of the extra protein required by young stock and lactating breeders.

- Although the principles involved in the use of non-protein nitrogen for protein synthesis by rumen organisms are becoming better understood, we have not yet sufficient information to enable us to use urea efficiently as a major source of dietary nitrogen in the field.