Urea for Dairy Cattle

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Urea for Dairy Cattle

by N. A. JORGENSEN, assistant professor of dairy science
E. V. KURTZ, extension dairyman; and E. J. KLEEN, assistant extension dairyman

Urea has been used successfully for several years as a nitrogen supplement in rations for mature ruminants. It is the non-protein nitrogen source most commonly used to add nitrogen to rations economically. Research has established guidelines for urea-feeding programs when coupled with good management and proper sanitation. To date, no research has indicated that rations containing urea have any effect on reproduction or sterility or on vitamin A nutrition of ruminants. Balancing the ration for all nutrients will assure maximum production of milk and meat.

WHAT IS UREA?

Urea is a white, crystalline, water-soluble, synthetic chemical made by taking nitrogen from the air and combining it under heat and pressure with carbon, hydrogen, and oxygen. Urea is not a natural protein and it has no food value, but when it is added to a high-energy ration, it serves as an excellent source of nitrogen for conversion into protein by rumen bacteria.

Chemically pure urea contains 46.65 per cent nitrogen. Commercial feed-grade urea is usually 42 or 45 per cent nitrogen.

"Crude protein equivalent" is a feedstuff's maximum potential protein value if all its nitrogen is converted to protein by the rumen organisms. One pound of 45 per cent urea is equal to 2.81 pounds of crude protein if converted completely into useable protein by the rumen bacteria. This is equal to the crude protein content of 6.4 pounds of soybean meal (44 per cent).

Fertilizer-grade urea contains about 46 per cent nitrogen, but it is not approved for use in livestock feeding.

Utilization of Urea by Ruminants

When urea-containing rations are fed to ruminant animals, the urea is rapidly broken down into ammonia (NH₃) and carbon dioxide (CO₂) by the enzyme urease which is secreted by rumen microorganisms. Ammonia is also released into the rumen from natural protein feeds. The ammonia formed in the rumen from urea and other dietary nitrogen sources is combined with acids produced in the rumen, to form amino acids. The amino acids are then incorporated into the bodies of the rumen microorganisms. The proteins in the bodies of the microorganisms then are digested in the intestinal tract and absorbed into the cow's body.

The composition of the ration is important, insofar as the bacteria need a readily available source of energy, preferably starch as found in corn and molasses, for rapid growth and production of acids. Ammonia not utilized in the synthesis of microbial protein is absorbed through the rumen wall into the blood stream. Most of this is probably excreted into the urine. Thus, unless the rumen ammonia is utilized rapidly by the rumen organisms, it may be wasted.

UREA TOXICITY

Under proper feeding conditions urea toxicity is unlikely, but follow recommendations closely. Ammonia produces the toxic effects. Toxicity can result if too high a level of urea is fed, if it is not mixed thoroughly with other feed ingredients, or if it is not mixed into a proper ration.

Dairy cattle are more susceptible to urea toxicity when urea is fed with rations high in low-quality roughage or when they have not had access to feed for several hours. Higher levels of urea can be fed when the ration contains grain and molasses. High quality roughage also improves utilization.

Urea toxicity develops rapidly. Symptoms include uneasiness, muscle and skin tremors, excess salivation, labored breathing, incoordination, bloat, tetany, and death.

Acetic acid as a five per cent solution or as vinegar is an effective cure in many cases of urea toxicity, if given before the development of severe tetany. About one pint of a 5 per cent acetic acid or common vinegar per 100 pounds of body weight will generally be an adequate amount.

FEEDING RECOMMENDATIONS

Rumen bacteria need about three weeks to adjust to a urea ration. Sudden introduction of urea can cause palatability or toxicity problems. When feeding high-urea supplements, include urea at low levels and gradually increase until the desired level of feeding is reached. Never make a sudden change in the ration.

Urea is not used efficiently when the amount added exceeds the recommended levels or when it is added to rations already supplying sufficient protein from natural sources.

For efficient conversion of urea nitrogen into bacterial protein, add urea to grain mixtures low in protein and high in energy such as supplied by corn and molasses (readily available carbohydrates). Avoid use of low-quality grain screenings or other poor quality feeds.

Do not add urea to feeds containing raw soybeans or feed such as lespedeza seeds or screenings. These feeds contain the enzyme urease which breaks urea.
down into ammonia and carbon dioxide. The ammonia released will make the feed unpalatable and reduce the feed value.

Mixing

Thorough mixing of high-urea supplements into a complete grain mixture cannot be overstressed.

1. Mixing prevents large amounts of urea from being consumed in a short period—this may be toxic. Do not top-dress feeds (silage or other roughage) with high-urea supplements.

2. Mixing aids in masking the taste of urea. (Urea looks like common salt and tastes somewhat like Epsom salt.)

3. Mixing aids in providing rumen bacteria the proper balance of energy feeds and urea for maximum protein synthesis.

Addition of five per cent liquid molasses tends to reduce the sifting out of urea from coarsely ground grain mixtures and improves the palatability of the feed.

Amounts

Crude protein (nitrogen) equivalent from urea and other non-protein nitrogen sources should not exceed more than ½ of the total crude protein (or nitrogen) in the ration. The following are accepted rules of thumb for maximum levels of urea:

- one per cent urea by weight of total air-dry ration
- three per cent urea by weight of total grain ration
- up to ½ pound per cow per day

Although three per cent urea can be added safely to the grain mix when cattle are provided an excellent forage ration, palatability may become a problem. To assure palatability and efficient utilization of urea-nitrogen, follow the recommendations summarized in Table 1. for maximum levels of urea to add to the grain mixture.

Dairymen feeding a complete feed can safely add one per cent urea or 20 pounds per ton in the complete ration mixture. When adding urea to the ration on a percentage basis, calculate daily intake to see that it does not exceed the above rules of thumb.

Commercial Supplement

Some dairymen may prefer to purchase commercial high-protein supplement with urea rather than buy feed-grade urea for mixing. If urea is present in a supplement, the feed tag will carry a statement indicating the maximum percentage of crude protein equivalent from non-protein nitrogen (see example). If the feed contains more than three per cent urea or if the crude protein contributed by urea exceeds one-third of the total crude protein, the label should bear a statement of proper use. The name of the substance supplying the non-protein nitrogen must appear in the ingredient list on the feed tag. If you are uncertain whether 42 or 45 per cent nitrogen urea is included, ask your feed dealer. Read all labels carefully.

GUARANTEED ANALYSIS

<table>
<thead>
<tr>
<th>Crude Protein, not less than 80.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(This includes not more than 56.2% equivalent protein from non-protein nitrogen.)</td>
</tr>
<tr>
<td>Crude fat, not less than 2.5%</td>
</tr>
<tr>
<td>Crude fiber, not more than 8.5%</td>
</tr>
</tbody>
</table>

Ingredients: Soybean meal, Cottonseed meal, Linseed meal, Cane molasses, Urea, Vitamin A Palmitate, etc.

From the information given on the guaranteed analysis, you may calculate the amount of urea in the feed. For example, consider the information on the example feed tag.

Step 1. Calculate % urea in the feed:

\[
\text{% Crude protein equivalent from non-protein nitrogen} = \left( \frac{\text{Crude nitrogen of the feed-grade urea}}{\text{Crude protein equivalent of the feed-grade urea}} \right) \times 100 \\
\]

\[
\text{Step 2. Calculate pounds of urea in premix or supplement:} \\
\text{= lbs. of supplement in bag x % urea} \\
\text{= 100 lbs. x 20%} \\
\text{= 20 lbs.}
\]

When the amount (pounds) of urea in each bag of supplement is known, safe levels of addition to the grain mixture can be determined. Use the levels given in Table 1.

Step 3. Calculate pounds of urea needed to make a ton grain mixture containing 2% urea or the level desired:

\[
\text{lbs. urea needed} = 2000 \text{ lbs.} \times 2\% \\
\text{= 2000 x .02} \\
\text{= 40 lbs.}
\]

*Most urea contains 281\% crude protein equivalent, however some may contain 262\%.

### Table 1. Amount of Urea to Add to the Grain Mixture

<table>
<thead>
<tr>
<th>Level of grain feeding (pound per cow per day)</th>
<th>% Urea in Grain</th>
<th>Pounds urea/ton grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 20</td>
<td>2.0%</td>
<td>40 lbs.</td>
</tr>
<tr>
<td>Up to 25</td>
<td>1.5%</td>
<td>30 lbs.</td>
</tr>
<tr>
<td>Over 25</td>
<td>1.0%</td>
<td>20 lbs.</td>
</tr>
</tbody>
</table>

From the information given on the guaranteed analysis, you may calculate the amount of urea in the feed. For example, consider the information on the example feed tag.
Step 4. Calculate pounds of supplement that will supply this amount of urea:

Supplement needed = 40 lbs. urea needed

20 lbs. urea / bag of supplement
= 2 bags or 200 lbs. of supplement

Since most supplements contain minerals and vitamins, in addition to protein, calculate the amount of each to add to the grain mixture.

Calculating Total Protein from Urea and Total Protein in the Grain Mixture

In order to calculate the total crude protein equivalent from urea, information must be obtained on the amount of urea in the total ration. Use the example in Table 2.

Table 2. Grain Mixture

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>lbs.</th>
<th>% Crude Protein</th>
<th>lbs. Crude Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelled corn</td>
<td>1320</td>
<td>9.5</td>
<td>125.4</td>
</tr>
<tr>
<td>Oats</td>
<td>500</td>
<td>12.5</td>
<td>62.5</td>
</tr>
<tr>
<td>Molasses</td>
<td>100</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Urea (281%)</td>
<td>40</td>
<td>281.0</td>
<td>112.4</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>20</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>TMS</td>
<td>20</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>2000</td>
<td>300.3</td>
<td></td>
</tr>
</tbody>
</table>

Total per cent crude protein in grain mixture equals 300.3 / 2000 = 15%.

The protein equivalent furnished by 40 lbs. of urea equals 40 x 281 = 112.4 lbs.

Protein equivalent furnished by urea in grain mixture equals 112.4 / 300.3 = 37.4%.

The above grain mixture contains 37.4 per cent crude protein equivalent from urea. Addition of other feeds such as forages would decrease the per cent of total crude protein equivalent in the ration supplied by urea to a safe level (one-third, 33 per cent of the total crude protein in the total ration or less).

Since natural proteins are high in phosphorus and energy, be sure to balance these in the ration when substituting urea for natural proteins. Dicalcium phosphate or defluorinated phosphate should be the minerals of choice. Add one per cent or 20 pounds to the grain mix. Also add one per cent trace mineral salt to meet minor element requirements. Select a trace mineral salt which contains 0.4 to 0.8 per cent zinc. Since sulfur is present in the proteins in the sulfur-containing amino acids, added sulfur is needed in the ration when urea replaces all or part of the natural protein supplement. Generally the sulfur needs will be met by adding 1 per cent trace mineral salt to the ration (20 pounds per ton). Three pounds of Glaubers salt (sodium sulfate) per 10 pounds of urea used in the ration should meet the requirements for sulfur.

Be sure vitamin content of the ration is adequate whether or not urea is fed. The importance of vitamins A and D should not be overlooked, especially during the winter and early spring. The vitamin-A requirement for milking cows is about 30 to 40,000 IU per day and about 5 to 10,000 IU per day for vitamin D. Base supplementation on the quality of the total ration. Supplementation of 50 to 75 per cent of the required levels is recommended during winter and spring.

Can Urea Be Fed to Growing Heifers?

The rumen of a newborn calf is non-functional at birth and the calf is called a simple stomach animal. It is not advisable to feed urea to calves less than three months old. After that the rumen is functional. All ruminants can utilize urea as a source of nitrogen. The level of urea for mature animals will apply to growing heifers if good quality forage is fed.

Urea-Treated Corn Silage or High Moisture Corn

Research on the addition of urea to corn silage or high moisture corn is not conclusive. Generally one may expect some nitrogen loss due to fermentation in the silo. The extent of the loss will depend on the nature of storage.

However, the addition of 10 pounds of urea per ton of corn silage at the time of ensiling in good upright silos will produce an acceptable product. Levels above this are not recommended.

Consider also the bushel yield of the corn crop to be ensiled. The lower the bushel yield, the less urea should be added to the corn silage. For example: if the yield of ear corn is 50 bushels per acre, 5 pounds of urea per ton of corn silage ensiled may be the upper limit to use. Adding 10 pounds of urea to a ton of corn silage containing 33 per cent dry matter will increase the crude protein equivalent from 2.8 per cent to 4.2 per cent on an as-fed basis (8.5 per cent to 12.5 per cent on a dry matter basis).

Feeding urea with silage spreads consumption over a longer period of the day and this may improve utilization. However, urea-treated silage may limit the flexibility of the total feeding program, whereas adding urea to the grain will allow you more frequent change in total ration make-up. Plan your feeding program early.

Examples of Grain Mixtures

Using a synthetic non-protein nitrogen source (urea) in a dairy ration is a matter of economics. Although an excellent source of nitrogen, urea supplies no energy, no minerals, and no vitamins to the ration. Consequently, be sure that rations containing urea remain well-balanced in all nutrients. Check the cost of your grain mixture. Does it supply the energy, protein, mineral, and vitamin levels needed to obtain maximum efficiency from your herd?

The grain mixtures in Tables 3 and 4 serve as examples of substituting urea for part of the crude protein content. All are satisfactory for dairy cattle when coupled with the proper forage program.
Table 3. Grain mixtures with 10-14% crude protein content (with and without UREA) to be fed with high-protein forages.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Unit</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelled Corn</td>
<td>lbs.</td>
<td>1200</td>
<td>1400</td>
<td>1200</td>
<td>1000</td>
<td>1210</td>
<td>1290</td>
<td>1440</td>
</tr>
<tr>
<td>Corn and Cob Meal</td>
<td>lbs.</td>
<td>760</td>
<td>470</td>
<td>480</td>
<td>840</td>
<td>500</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Oats</td>
<td>lbs.</td>
<td>200</td>
<td>200</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Soybean Meal (44%)</td>
<td>lbs.</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>UREA, 45% N</td>
<td>lbs.</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Molasses, blackstrap</td>
<td>lbs.</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>lbs.</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Trace mineral salt</td>
<td>lbs.</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Calculated Analysis:

**Crude Protein %**

9.8 10.3 12.5 12.2 13.8 14.1 13.7

**Estimated net energy, therms**

75.5 78.5 78.8 73.9 76.4 77.2 77.7

**UREA (by weight) %**

0.0 0.5 0.0 1.0 0.0 1.0 1.0

*These are example rations; other higher protein supplements such as cottonseed meal or linseed meal can be used. Likewise, milo, barley, or other grains can replace corn and oats.

*Steamed bonemeal or defluorinated rock phosphate can be used in place of dicalcium phosphate, provided the phosphorus level in the ration is adequate.

*Balance vitamins A and D according to forage quality and season.

*Calculated on an as-fed basis.

Table 4. Grain mixtures with 14-18% crude protein content (with and without UREA) to be fed with low-protein forages.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Unit</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelled Corn</td>
<td>lbs.</td>
<td>1200</td>
<td>1300</td>
<td>1250</td>
<td>1300</td>
<td>1000</td>
<td>1100</td>
<td>1100</td>
</tr>
<tr>
<td>Corn and Cob Meal</td>
<td>lbs.</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Oats</td>
<td>lbs.</td>
<td>435</td>
<td>495</td>
<td>560</td>
<td>340</td>
<td>445</td>
<td>310</td>
<td>520</td>
</tr>
<tr>
<td>Soybean Meal (44%)</td>
<td>lbs.</td>
<td>325</td>
<td>25</td>
<td>400</td>
<td>250</td>
<td>75</td>
<td>550</td>
<td>200</td>
</tr>
<tr>
<td>UREA, 45% N</td>
<td>lbs.</td>
<td>40</td>
<td>20</td>
<td>40</td>
<td>20</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Molasses, blackstrap</td>
<td>lbs.</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>lbs.</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Trace mineral salt</td>
<td>lbs.</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Calculated Analysis:

**Crude Protein %**

15.0 14.8 15.9 15.8 15.6 18.3 17.9

**Estimated net energy, therms**

78.1 76.4 72.2 77.2 76.4 76.9 74.4

**UREA (by weight) %**

0.0 2.0 0.0 1.0 2.0 0.0 2.0

*These are example rations; other higher protein supplements such as cottonseed meal or linseed meal can be used. Likewise, milo, barley, or other grains can replace corn and oats.

*Steamed bonemeal or defluorinated rock phosphate can be used in place of dicalcium phosphate, provided the phosphorus level in the ration is adequate.

*Balance vitamins A and D according to forage quality and season.

*Calculated on an as-fed basis.

Ask for these dairy production fact sheets:

FS 403 "Milk Production"
FS 404 "The Milking Machine"
FS 405 "Screening Tests for Abnormal Milk"

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John T. Stone, Dean of Extension, South Dakota State University, Brookings.

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