UREA AND OTHER NONPROTEIN NITROGEN COMPOUNDS FOR CATTLE AND SHEEP

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NEARLY 75 YEARS AGO researchers recognized that nonprotein nitrogen (NPN) compounds are utilized by bacteria in the rumen of cattle and sheep. Studies since that time have shown that these compounds are broken down to ammonia during the normal fermentation process in the rumen. Micro-organisms in the rumen combine the ammonia with products of carbohydrate metabolism to form amino acids and hence proteins. The proteins formed in this manner (from NPN compounds) are similar in amino acid content to the proteins formed when the principal source of nitrogen is an intact protein.

The bacteria and protozoa, and the protein they contain, are digested by the animal farther on in the digestive tract. In this manner the ruminant animal makes use of certain NPN compounds even though it does not possess enzymes of its own for their breakdown. Animals with simple stomachs (pigs and chickens) cannot make use of large concentrations of nonprotein nitrogen compounds because of a lack of enzymes and bacteria to break down the NPN to ammonia and synthesize it into protein.

NPN Common in Ruminant Feeds

Many of the common feedstuffs fed to livestock contain some NPN. Oil meals contain about 0.25 percent of their total nitrogen as urea while oats may contain 4.5 percent. Forages are generally higher in NPN than concentrates, and young plants may contain as much as 15 percent of their total nitrogen as NPN, while mature plants usually contain less than 5 percent of the nitrogen in this form. This indicates that certain feeds contain nonprotein nitrogen and that nonprotein nitrogen is not a foreign substance in ruminant rations.

Commercial Sources of NPN

The most common source of NPN used in ruminant feeding is urea. Many other products have been used experimentally and commercially, but most of them do not compare favorably to urea because of greater toxicity, higher cost, or lower palatability. Urea and some of the other common sources of NPN are discussed below:

Ammoniated products—Many low-protein feeds and byproducts of the milling industry have been ammoniated and fed as sources of nitrogen for ruminants. Examples are ammoniated molasses, ammoniated condensed distillers' molasses solubles, ammoniated citrus pulp, ammoniated beet pulp, and ammoniated furfural residue. These products have generally been found to be less satisfactory than urea as a protein substitute; in some instances they have been more toxic and less palatable than urea. These products cannot be stored for a great length of time, especially under moist conditions, because much of the ammonia will be lost as a gas.

Ammonium salts—Diammonium phosphate (DAP) and monoammonium phosphate (MAP) are two ammonium salts that show promise as sources of nonprotein nitrogen and phosphorus. Recent work conducted at the Oklahoma Agricultural Experiment Station indicates that DAP was a satisfactory source of phosphorus but its nitrogen was not retained by sheep as well as that supplied by urea. Rations containing DAP were also less palatable than those containing urea because of ammonia losses when the feed came in contact with water or saliva. Coatings developed by some mineral manufacturers may improve the utilization of these compounds.

Biuret—Biuret is formed by heating urea. It is less soluble and is broken down to ammonia at a slower rate than urea. This slower rate of decomposition makes it less toxic than urea when fed in large doses because there is not a rapid buildup of ammonia levels. As a protein substitute it appears that biuret is as good as urea.

Urea—Urea is a simple compound that contains 46.7 percent nitrogen. It is found in many plants and is a normal end product of protein metabolism in mammals. A part of the urea produced in the animal body is returned to the digestive tract by the saliva. One-third to one-sixth of an ounce of urea may be returned to the rumen daily in this manner. The remainder of the urea is passed off in the urine as waste.

One pound of pure urea furnishes as much nitrogen as 2.92 pounds of protein (protein equivalent of 292 percent). The feed grade of urea has other ingredients, such as kaolin, wheat middlings, rice hulls, or limestone added to it to prevent caking and lumping. This material lowers the protein equivalent to 281 or 262 percent, depending on the amount added. The "281" urea has recently become the most popular.

Urea a Protein Replacement

Urea is fed to ruminants as a replacement for a part of the protein in the ration. Urea is not necessary in the diet of these animals; it is a replacement for protein, and whether or not it is used is simply a matter of cost of urea in relation to high-protein feeds. With the present cost of commercial protein supplements it is economical to use urea as a protein supplement in ruminant rations. If sufficient protein is furnished by home-grown feeds, feed costs will not be lowered if urea is added.

Using the protein equivalent of 281 percent, 13.5 pounds of urea and 86.5 pounds of corn or similar grain are equal in protein and energy value to 100 pounds of 44 percent protein soybean meal or similar protein supplement for ruminant animals. The cost of the urea-corn mixture would be less than $50 per ton (urea, $100 per ton; corn, $40 per ton). When soybean meal sells for about $80 a ton urea will reduce protein supplement costs.

Requirements for Urea Utilization

The most important single factor required for urea utilization is a ration with adequate starch (supplied in large quantities by cereal grains). Sugars and cellulose are inferior to starch for maximum urea utilization: Sugars pass out of the rumen too rapidly and cellulose is not broken down fast enough to supply energy and breakdown products for conversion of urea to protein. Starch remains in the rumen for a long enough period of time and provides a uniform supply of carbohydrate. Molasses may be beneficial for urea utilization, especially if the ration is low in starch.

Rations that are low in readily available true protein also favor urea utilization. This does not necessarily mean that urea should be added only to rations extremely low in protein, but indicates that rations approaching the necessary protein content will benefit little by adding urea. This same effect holds true when adding true protein to a ration.

Supplemental Minerals Are Recommended

A ration may need supplemental minerals when a part of the protein supplement has been replaced with urea. This is not due to an increased need for these nutrients, but it is possible that the content of these nutrients will be lowered due to the removal of a part of the protein supplement. Most of the high-protein oil meals are high in phosphorus and relatively so in trace minerals. The free-choice feeding of a mixture of three parts dicalcium phosphate, one part ground limestone, and one part trace-mineral salt should supply sufficient quantities of minerals most likely to be lacking in the rations. In addition, University of Minnesota research indicates that sulfur should be added to urea-containing rations. Sulfur may be supplied by mixing 40 pounds of Glaubers salt or 4 pounds of elemental sulfur per ton of supplement.

Recommended Level of Urea Supplementation

Urea should not replace the equivalent of more than one-third of the protein in the grain or concentrate part of the ration. This recommendation has been established to minimize the possibility of urea toxicity when feeds containing urea are fed to ruminants. Urea poisoning should not be a problem if the above recommendation is followed or if the total ration does not contain over 1.5 percent urea.

Protein supplements that contain 10 to 12 percent urea may also be mixed, although the Minnesota Feed Law states that if a feed contains over 3 percent urea or if urea supplies over one-third of the protein equivalent that this be clearly stated on the feed tag and directions given for its use. Extreme caution must be exercised when adding much more than 10 to 12 percent urea to a supplement (even though when fed with the total ration it would not exceed the safety level), as large amounts lower supplement palatability. When high-urea supplements are fed they must be thoroughly mixed with the grain portion of the ration; this precaution will prevent individual animals from consuming toxic amounts of urea.

Urea Toxicity

Urea toxicity (poisoning) may be a problem if urea is fed at levels higher than those recommended. Most instances of urea poisoning are due to poor mixing of feed or to errors in the calculations of the amount of urea to add to the ration. If the proper level of urea is added to the ration and it is mixed uniformly there should be no problem with urea toxicity.

Urea toxicity is characterized by the following clinical signs: uneasiness, tremors, excess salivation, rapid breathing, incoordination, bloat, and tetany. These symptoms usually occur in about the same order as listed above. Tetany is the last symptom observed before death occurs. Laboratory findings of urea toxicity are a sharp rise in blood ammonia levels and a rise in rumen pH. Animals usually die when the blood ammonia level reaches 5 mg. per 100 ml. of blood. Rumen pH will rise to about 8, and the normal function of the rumen will cease.

Extremely high levels of urea may be fed to ruminant animals if the level is increased gradually. This adaptation to high levels of urea is lost rapidly when urea is removed from the ration. *Animals that have been off* feed for 1 or 2 days are also more susceptible to urea poisoning. For these reasons care should be exercised when urea is added to the diet after a period of feeding without urea.

A local veterinarian should be called to treat cases of urea toxicity. As an *emergency* measure, 1 gallon of vinegar may be administered to cattle as a drench. Acetic acid furnished by the vinegar lowers rumen pH and neutralizes ammonia, thus preventing further absorption of ammonia into the bloodstream.

Practical Considerations

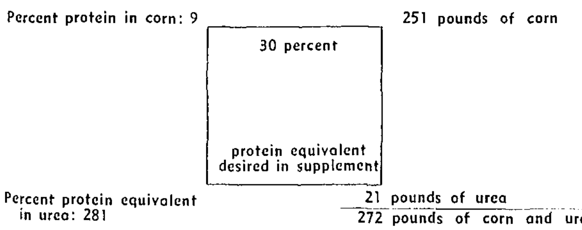
Because urea should not supply more than one-third of the total protein in the grain or concentrate portion of the ration, protein supplements to be fed with only pasture and roughage could contain 1.19 percent ($\frac{1}{3} \times 10 \div 2.81$) for each 10 percent of protein.

> **For example: a 30-percent protein supplement could contain 3.6 percent urea (1.19 × 3) and a 40-percent protein supplement 4.8 percent urea (1.19 × 4).**

If 4 pounds of timothy hay (6.8 percent protein), 15 pounds of corn grain (9.0 percent protein), and 2 pounds of protein supplement (30 percent protein) were to be fed to a fattening beef steer how much urea could be fed daily?

> **The protein furnished by the hay is not considered; therefore, the amount of protein that may be replaced with urea is 0.59 pound (15 pounds corn × 9 percent protein + 2 pounds of supplement × 30 percent protein = 1. 95 pounds protein of which a maximum of one-third may be supplied by urea). Thus, 0.59 ÷ 2.81 = 0.21 pound of urea may be fed.**

How to Use the Pearson Square



1. Set up the square as shown above to formulate a supplement containing 30 percent protein equivalent from corn and urea.

2. Subtract the smaller number from the larger on the diagonal: 30 — 9 = 21 pounds of urea and 281 — 30 = 251 pounds of corn.

3. To obtain a supplement containing 30 percent protein equivalent, 251 pounds of corn and 21 pounds of urea are required.

4. The corn-urea mixture (251 pounds of corn + 21 pounds of urea = 272 pounds) is 7.7 percent urea (21 pounds urea ÷ 272 pounds of corn-urea) and 92.3 percent corn (251 pounds corn ÷ 272 pounds of corn-urea).

Using the Pearson square method, a 30-percent protein supplement could be formulated by mixing 7.7 parts of urea and 92.3 parts of corn. When fed at 2 pounds per day this supplement would furnish 0.15 pound of urea, which is below the recommended maximum.

A *special situation arises* when corn silage or ground ear corn are fed, since these feeds are not 100 percent roughage. Corn silage with average grain content can be expected to furnish approximately 16 pounds of air-dry corn grain per 100 pounds of silage. Ground ear corn *is about 80 percent corn grain.* A daily ration of 12.5 pounds corn silage, 15 pounds ground ear corn, and 2 pounds of a 40-percent protein supplement could, therefore, safely contain urea. The silage furnishes 2 pounds of corn and the ground ear corn supplies 12 pounds.

> **Calculations: 14 pounds corn × 9 percent protein + 2 pounds supplement × 40 percent = 2.06 pounds of protein, of which one-third may be supplied by urea. Therefore, 0.63 pound of protein equivalent may come from urea. This amount would be furnished by 0.22 pound of urea (0.63 ÷ 2.81), and the 2 pounds of 40-percent protein supplement could be formulated by mixing 0.23 pound of urea and 1.77 pounds of ground shelled corn.**

From the above calculations it is evident that the amount of protein furnished by urea *may be determined* by multiplying the percent urea by 2.81. If a 40-percent protein supplement contains 8 percent urea, 22.48 percent protein is furnished by urea (8 × 2.81) and 17.52 percent by other ingredients. The percent of total protein furnished by urea may be calculated by *dividing* the percent of protein as urea by the percent protein in the supplement. In the above example slightly more than 56 percent of the protein is furnished by urea (22.48 ÷ 40).

When the amount of urea in a supplement *is* expressed as percent protein as urea, the percent urea may be calculated by dividing this value by 2.81.

> **For example: If a 40-percent protein supplement has 10 percent protein as urea, it contains about 3.6 percent urea (10 ÷ 2.81). In this instance 25 percent of the protein is furnished by urea (10 ÷ 40).**

Summary

1. Nonprotein nitrogen compounds can be economically used to replace a part of the intact protein in rations for ruminants. These compounds are used as a method of adding protein to a ration at a lower cost than with conventional high-protein feeds. Urea is the most common of the nonprotein compounds used in ruminant feeding.

2. Urea should not replace more than one-third of the protein in the concentrate part of a ration.

3. Rations with a high cereal grain content favor urea utilization.

4. Additional minerals should be supplied where a part of the protein supplement is replaced with urea. A simple, free-choice mineral mixture will supply these nutrients.

5. Toxicity should not be a problem if urea is fed according to recommendations. Urea poisoning is less of a problem with rations containing molasses. Vinegar is a helpful treatment for urea poisoning if the animal is treated before tetany develops.

6. Protein supplements containing high urea levels should be mixed thoroughly with the complete ration to prevent palatability and toxicity problems.

7. Undiluted urea preparations are not recommended for home mixing because of the importance of accurate and uniform mixing.

8. It is usually not advisable to replace all of the high-protein supplement with urea.

9. Urea has limited use in rations low in protein and high in roughage because of the small amount that may be added and still remain within the recommendation that no more than one-third of the protein be supplied by urea, excluding the pasture and roughage. This recommendation has been established because roughages do not furnish adequate amounts of readily available energy.

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