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Cattle Feeding

Urea supplements for beef cattle

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Urea supplies part of the protein equivalent in many of the commercial supplements formulated for beef cattle today. When soybean meal and other plant proteins are high in price, more urea is used to replace plant protein in the ration of beef cattle and sheep.

Urea is a non-protein nitrogen (NPN) compound. The urea used in livestock feeds is a synthetic compound manufactured on a large scale for fertilizer and feed use.

The simple urea compound contains 46.7 percent nitrogen. Most of the urea used in livestock feeds has 45 percent nitrogen but some has 42 percent. Feed grades of urea have less nitrogen than the pure compound because the particles of urea are coated with clay or treated with formaldehyde or other material to prevent caking and lumping.

Protein equivalent

Feeds are analyzed for nitrogen in the laboratory to determine their crude protein. Protein averages 16 percent nitrogen. Thus, the percent nitrogen multiplied by 6¼ gives the percent crude protein analysis. Therefore, urea with 45 percent nitrogen has a protein equivalent of 281 percent (45 x 6¼) for ruminants. Urea with 42 percent nitrogen has a protein equivalent of 262 percent (42 x 6¼). This is the reason urea with 45 percent nitrogen or 42 percent nitrogen is often designated as "281" or "262" urea, respectively.

How do cattle use urea?

Cattle, sheep and other ruminants can use urea to replace part of the protein in their diet because of the host of microorganisms (bacteria and protozoa) present in their rumen. More than half of the protein consumed by cattle is broken down in the rumen into peptides, amino acids and ammonia by the action of enzymes manufactured by these microorganisms. Urea $(NH_2)_2C=O$ is degraded to carbon dioxide (CO_2) and ammonia (NH_3) in the rumen by a similar process.

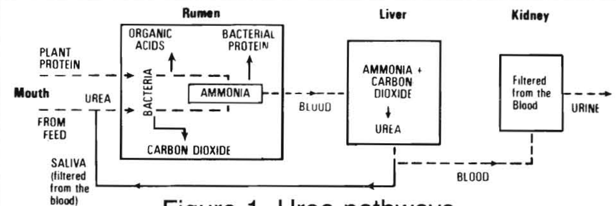

Figure 1. Urea pathways.

In their multiplication and growth, rumen microorganisms use the ammonia released from the breakdown of protein and nonprotein nitrogen compounds (urea, etc.) to manufacture microbial protein. The bacteria and protozoa produced in the rumen pass further down the digestive tract and are digested, making the proteins from their cells available to the host animal.

When can cattle use urea?

For cattle to use urea, microorganisms in the rumen must be able to convert the ammonia released from the urea into microbial protein. Urea is highly soluble in the rumen, and microorganisms rapidly decompose it to ammonia and carbon dioxide. The ammonia released from the urea can go two pathways (Figure 1). It can be made into microbial protein. It can also build up and be absorbed through the rumen wall into the blood stream, which carries it to the liver.

The liver detoxifies ammonia by converting it to urea to be excreted in the urine. Some of the urea is recycled to the rumen, however, through saliva and by absorption from the blood through the rumen wall. However, if ammonia escapes the rumen too rapidly, the capacity of the liver is exceeded and ammonia spills into the main blood system. High levels of ammonia circulating in the blood can cause toxicity or even death. This suggests that if urea is to be an effective source of true protein for cattle, conditions in the rumen must be favorable for microorganisms to use the ammonia from urea before it escapes the rumen. Thus, whenever ammonia is overflowing in the rumen and bacteria already have sufficient ammonia for metabolism, additional urea in the ration is of no value in meeting the protein needs of cattle.

The amount of urea that can be used by rumen microorganisms will depend upon the number of microbes and how rapidly they are growing and whether ammonia and other essential nutrients are available when needed. Microbes need vitamins, minerals and a readily available source of energy for fast growth. Therefore, more ammonia can be utilized when high energy feeds are fed. Cattle fed high grain finishing rations can make greater use of urea in their ration than cattle fed low energy roughage rations.

Urea fermentation potential (UFP)

Iowa State University scientists have developed a system for evaluating the urea fermentation potential (UFP) of feeds to estimate the amount of urea that can be useful in any cattle ration. A positive UFP value of a feed or ration can be defined as the estimated grams of urea per kilogram of feed dry matter consumed (or pounds per 1,000 lbs.) that can be useful in fermentation by microorganisms in the rumen of cattle. A positive UFP value implies that this quantity of urea feeding is a satisfactory level for achieving maximum or near maximum formation of urea-nitrogen into microbial protein.

Calculation of a UFP value involves the amount of fermentable energy present in a feed and the amount of ammonia formed from breakdown of the protein in a feed by rumen fermentation. A feed with a positive UFP value is one that has more fermentable energy present than that needed for transforming the ammonia degraded from its own protein into rumen microbial protein.

For example, corn is given a positive UFP value of 11.8 which means 11.8 grams of urea is useful for fermentation by rumen bacteria for each kilogram (1,000 grams) of corn dry matter fed. Another way to express this would be that 1.18 pounds of urea can be used by bacteria for each 100 pounds of corn dry matter fed (1.18 percent). UFP values for selected feeds are shown in Table 1.

A feed with a negative UFP value is one that has less fermentable energy than that needed to transform into microbial protein all the ammonia arising from the breakdown of its protein during rumen fermentation. Urea addition to this type of feed would be of no value in satisfying the metabolizable protein requirements of the ruminant host. Urea would only add to the surplus nitrogen load in the rumen. An example is fescue hay with a negative UFP value of -0.87. This value indicates that the available energy in fescue hay is not great enough to transform to microbial protein all the nitrogen that is released by the degradation of its own protein in the rumen.

TABLE 1—Urea Fermentation Potential (UFP)[1]
(values on dry matter basis)

Feed	TDN%	Protein%	Est. % Protein Degraded in Rumen	UFP[2]
Corn	91	10	62	1.18
Milo	80	12.4	52	0.68
Oats	76	13.2	70	-0.47
Corncobs	47	2.8	75	1.0
Corn Silage	70	8.1	68	0.64
Fescue, Hay	62	10.5	85	-0.87
Orchard Grass	57	9.7	85	-0.82
Soybean Meal	81	51.5	75	-10.7

[1]Selected feeds from Table 1 prepared by Iowa State University scientists.
[2]The lbs. of urea that can be fermented for 100 lbs. of dry matter in the feed. Gm/kg given in original table were converted to lb./100 lbs.

Soybean meal is another feed that is given a negative UFP value (-10.7). The negative UFP value of soybean meal is caused by the large nitrogen release in the rumen with this feed because of the high solubility and high percentage of protein in soybean meal. Even though it is a high-energy feed, the large nitrogen release outstrips the energy available to convert it to bacterial protein.

Therefore, according to the values calculated for this system a ration composed entirely of corn would profit by the addition of 1.18 percent urea (11.8 g/kg). Adding larger amounts of urea would be of no value in supplying metabolizable protein post-ruminally, since this is the maximum amount of urea that can be converted to bacterial protein with corn. The urea fermentation potential (UFP) value of a ration is determined by totaling the positive and negative UFP value of the individual feed ingredients. A ration composed of corn and fescue hay would have a lower UFP value than corn alone.

Keep in mind these values are only guides for the use of urea in beef cattle rations. The protein and energy levels of the feed and other factors would change these UFP values. Fescue hay with more energy and less protein than that given in Table 1 could have a positive UFP value.

Urea can cut costs

Urea can reduce the cost of beef cattle rations. In some experimental comparisons, urea has reduced feed cost by 1¢ for each pound of beef gain, or a total of $4 to $6 a steer.

Urea has protein value in a beef ration, but it does not furnish energy, vitamins or minerals. It takes 0.68 pounds of (281) urea, 4.5 pounds of corn, 0.10 pounds dicalcium phosphate and 0.17 pounds of potassium chloride to furnish the same amount of nutrients contained in 5 pounds of (45.8 percent) soybean meal. These amounts of replacement feeds can be used to figure whether urea or soybean meal will supply

TABLE 2—Value of Soybean Meal ($/Ton) with Urea and Corn at Various Prices

Value Urea ($/ton)	200	250		300
Corn ($/bu.)	Value SBM $/ton	Value SBM $/ton		Value SBM $/ton
2.00	101.75	108.50	16	115.25
2.50	117.75	124.50		131.25
3.00	133.75	140.50		147.25
3.50	147.75	156.50		163.25
		6.75		

Price: Dicalcium phosphate, $160/ton; potassium chloride, $120/ton; mixing urea supplement, $3/ton.

protein equivalent more cheaply in a beef cattle ration (Table 2).

For example, urea is worth $300 a ton to supply protein equivalent, when corn costs $2.50 a bushel and soybean meal costs $131.25 a ton (Table 2). Any reduction in performance of the cattle fed urea would have to be deducted from the value of urea to replace soybean meal in a ration. Note that if the corn price remains constant, a $6.75 a ton increase in soybean meal increases the replacement value of urea by $50 a ton. Likewise, for every 50¢ a bushel increase in the price of corn, soybean meal is worth $16 more a ton to supply protein equivalent when the price of urea is held constant. These values can be used to expand the range of prices listed in Table 2.

For best urea use

Energy. Microorganisms must have energy and carbohydrates to use urea to make protein. It is important to have ammonia released simultaneously with available energy and carbon skeletons for ammonia to be converted to microbial protein.

Starch from grain is the best source of energy for urea utilization. Molasses is good, but its highly fermentable sugars are used up too quickly. Energy from roughages is made available too slowly in the rumen for good utilization of urea by bacteria. Thus, cattle on high-grain rations can derive a larger percentage of their protein needs from urea than cattle on roughage rations.

Feed 2-plus times a day. Allowing the animal to eat several times daily to provide a more uniform entry of urea into the rumen helps prevent a burst of ammonia release that may exceed the capacity of bacteria to utilize it.

Mix uniformly in ration. Urea must be mixed uniformly through the feed to prevent overconsumption of urea by individuals. Horizontal, commercial-type mixers should be used to mix urea supplements. Don't mix urea into a ration with a scoop shovel. Do not top-dress high-urea supplements over feed in a bunk.

Feed plant protein supplements at start. Feed plant protein supplements for the first 20 to 30 days, and then change to a urea supplement. This can lessen the lag in daily gain that often occurs when cattle are first started on urea supplements. Even cattle fed high-grain rations tend to gain more slowly at first when urea supplements are fed in comparison to plant protein supplements. This "lag period" with urea supplements usually lasts longer with lightweight (under 600 pounds) than with heavyweight cattle.

New arrivals. Don't feed urea supplements to "shipped-in" cattle that have been starved or off feed for two to three days. Give them a chance to fill up with feed before they are fed urea supplements. Better yet, use plant protein supplements for the first 20 to 30 days after cattle are received.

Don't feed excessive levels of urea. Using urea to increase the protein level of high energy rations above 12 to 13 percent crude protein on a dry matter basis seldom gives any increase in performance for young cattle, whereas the use of plant protein to raise the protein to this level will often increase rate of gain for lightweight calves. This is because urea is of no value if the rumen's bacteria already have sufficient ammonia. Therefore, it would not be logical to expect a non-protein supplement to raise the effective protein level of the ration once the bacteria in the rumen can convert no additional ammonia. Use plant protein supplements for rations that have crude protein requirement above 12 to 13 percent (DM).

Minerals. Mineral requirements of the rumen microorganisms must be supplied if they are to make best use of urea. Also, the urea supplement may need to furnish minerals to correct the mineral deficiency of other feeds in the ration.

Calcium, phosphorus and potassium are the major minerals of concern in cattle rations. Trace minerals that are usually added to high-urea rations are cobalt, zinc and sulfur. Sulfur is necessary for bacteria to synthesize methionine and cystine, amino acids that contain sulfur.

A nitrogen-to-sulfur ratio of 15:1 or even 10:1 is recommended for urea supplements. This level of sulfur is recommended for the total ration. The amount of sulfur needed in the urea supplement is dependent upon the level of sulfur in the remainder of the ration. Sodium sulfate or flours of sulfur are effective sources.

Unidentified factors. Some trials have shown that adding dehydrated alfalfa meal to high-urea supplements is beneficial. Other work has indicated no significant improvement from alfalfa additions. Alfalfa is thought by some to supply helpful unidentified factors for urea utilization. In Ohio work, depression in feed intake and the unpalatability of high-urea dairy rations were eliminated by pelleting with alfalfa meal.

Other sources of unidentified urea-protein factors are distillers dried grains with solubles and distillers solubles.

Much of the value of distillers grain in a urea supplement could be the low solubility of its protein which causes rumen by-pass. Urea would supply ammonia for bacteria in the rumen while the distillers soluble would furnish by-pass protein, a combination similar to soybean meal that has been treated to decrease its solubility and thereby increase protein passage to the lower gut.

Levels to feed

- Urea should not supply more than one third of the protein equivalent in the total ration.
- For cattle on high-grain rations, limit urea to 0.23 pounds a head daily (.60 pounds protein equivalent). See Table 3 to figure pounds of urea fed daily.
- A minimum of 3 pounds of grain a head daily should be considered necessary for satisfactory urea utilization with sorgo silage or similar energy roughages. Larger amounts are desirable.
- For cattle on moderate-energy growing rations, limit actual urea to 0.15 pounds a head daily.

Use feed tag to figure percent urea in feed

The Missouri Feed Law requires that the feed tag state the percent equivalent crude protein in a feed that is derived from nonprotein nitrogen. For example, a feed tag on a protein supplement states the following: Crude protein, not less than 40 percent. Crude protein from nonprotein nitrogen not more than 14 percent.

Question: What percent urea does this supplement contain?

Answer: If urea with 262 percent protein equivalent was used:

$$\frac{14 \times 100}{262} = 5.34\%$$

If urea with 281 percent protein equivalent was used:

$$\frac{14 \times 100}{281} = 4.98\%$$

Special considerations

Low-energy rations. An examination of the UFP values for feeds listed in Table 2 gives an indication of whether urea supplements would be utilized by cattle consuming low-energy rations. You will notice that corncobs have a positive UFP value even though they are low in TDN. This is because they have both low-content and low-degradable protein, each of which lowers the ammonia released in the rumen from fermentation. The energy level of cobs is calculated to be above that needed for bacteria to use the small amount of ammonia released in the fermentation of its protein. However, the amount of surplus energy sets a limit on how much the protein level of the cob ration can be raised with urea.

Table 3—Pounds of Actual Urea (281) Fed/Head Daily[1]

Protein Equiv. from Urea	Amount of Supplemental Fed/Head Daily ½ lb.	1 lb.	1½ lbs.	2 lbs.
10	.02	.04	.05	.07
20	.04	.07	.11	.14
30*	.05	.11	.16	.21
40	.07	.14	.21	.28
50	.09	.18	.27	
60	.11	.21		
70	.12	.25		

[1]Adapted from *Michigan Beef Cattlemen*, Vol. 1, No. 3.

*Example: The feed tag on a 40% protein reads: "Not more than 30% protein equivalent derived from NPN." This means that of the 40 units of protein, a maximum of 30 units is derived from urea and 10 from a vegetable protein source. When fed at the rate of 1½ lbs. a head daily, the foregoing table shows that the amount of urea (281) actually being fed is .16 pounds a head daily.

Fescue hay that has 5 percent crude protein might benefit from the addition of urea, while hay with 9 percent protein and similar energy would not have its protein equivalent raised for cattle when supplemented with urea.

Studies at Oklahoma State University indicated urea supplements were used 50-70 percent as efficiently as plant protein supplements to prevent weight loss in dry, pregnant cows grazing dry, winter range grass. The reproductive efficiency of the cows and the weaning weight of the calves were not affected materially by the type of supplement.

Urea supplements have been satisfactory for cows fed corn or sorghum silage in most trials. These feeds would be higher in energy and would likely need less protein supplementations for cows than is typical of winter range grasses.

Urea supplements have been inferior to plant proteins as supplements for weaner calves wintered on range grass in Nebraska trials. Biuret, a slow-release condensation product of urea, was intermediate in value to soybean meal and urea in these studies.

Slow-release products

Urea has been combined with starch from grain and the sugars in molasses through heat and chemical treatment to decrease the solubility of urea in the rumen and thereby slow the release of ammonia. Slow ammonia release or a more uniform ammonia level in the rumen throughout the day would be desirable for urea use with low-energy rations especially. A questionable factor in slow-release nitrogen compounds is the degree of degradation in the rumen. Some of the nitrogen in the urea may not become available for bacterial use.

There should be less danger of urea toxicity from overconsumption with slow-release products. The value of slow-release urea supplements to improve the utilization of urea for cattle fed low-energy rations has not been well established.

High-nitrate feeds

Investigations to determine whether urea additions increase the toxicity of high-nitrate rations are inconclusive.

Urea supplements have not affected performance of cattle on high-nitrate rations in some trials, but there have been indications of harmful effects in other cases and in field reports. The safe course would be to reduce the level of urea fed to cattle receiving feed or water with high-nitrate levels, especially during periods of ration change or adjustment.

Liquid vs. dry supplements

If the nutrient composition is the same, there is no difference in the feed value of liquid vs. dry urea supplements. Some advantages claimed for liquid supplements include: (1) they are easier to regulate consumption when self fed, (2) they require less labor to feed, and (3) they decrease dustiness of ration and loss from blowing.

Some disadvantages of liquid supplements could be: (1) they require greater transportation cost, unless liquid is added close to the feeding site; (2) there is a problem of keeping calcium and some other nutrients in solution. Calcium chloride stays in suspension in liquid supplements better than calcium carbonate does.

Urea effect on reproduction

There is no evidence that urea in the ration of breeding animals reduces fertility. Urea supplements have been compared with plant protein supplements for the nutrition of both male and female beef and dairy cattle at several experiment stations with no noticeable effect on reproduction efficiency.

There could be some reduction in reproduction if the urea supplement were used with low energy rations and if the protein requirements of the breeding animals could not be met with urea.

Oklahoma State University studies showed that pregnant cows at 3 or 4½ months of pregnancy did not abort when they were drenched with urea to the point that extreme antidote measures were needed to prevent death. All cows which recovered had a normal pregnancy and rebred as well as control animals.

Formulas for urea supplements

40 Percent Protein Equivalent

Ingredient	Urea
Corn, Shelled and Ground	72.2
Urea, Prilled (282% CP)	12.3
Potassium Sulfate	1.6
Dicalcium Phosphate (21% P)	1.9
Potassium Chloride	1.7
Salt, Trace Mineralized	10.0
Vitamin A (30,000 units/gm)	0.294

64 Percent Protein Equivalent (Purdue Dry 64 Supplement)

Ingredient	Pounds
Urea (45% N)	200
Cane molasses	140
Dehydrated alfalfa meal	510
Dicalcium phosphate	105
Iodized salt	35
Premix*	10
Total	1000

*Premix: 20 million IU vitamin A, 1250 gm. zinc oxide, 10 gm. DES, 4 gm. cobalt carbonate and 7 lbs. dehydrated alfalfa meal.

Purdue Liquid 64 (64% Protein)

Ingredient	Pounds
Liquid urea (32% N)	290
Cane molasses	385
Ammoniated polyphos (10-34-0)	90
Distillers solubles (27% dry matter)	93
Salt solution (28% salt)	90
Calcium chloride	12
Sodium sulfate	10
Premix[1]	30
	1000

[1]Premix: 20 million IU vitamin A; 10 gm. DES; 4350 gm. zinc sulfate; 9.5 gm. cobalt sulfate; 19 lb. water.

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