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Urea As a Protein Extender For Ruminants

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Much attention has been focused on urea in recent years by feed manufacturers, livestock men and experiment stations. The shortage of protein concentrates has aroused considerable interest in the possibility of replacing a part of the protein in rations for ruminants with non-protein nitrogen. Usually not enough high protein feeds are produced in the United States (or in the World) to adequately balance the rations for all farm livestock. If urea is used to replace a part of the protein supplements fed to ruminants, that part replaced can be made available to non-ruminants such as hogs and chickens, thus improving the nutrition of all farm livestock.

Urea is not a protein and it does not contain any protein. Urea simply contains large amounts of nitrogen that can be used indirectly by ruminants in place of protein. Nitrogen is an essential constituent of proteins, and is the element that distinguishes protein from fats and carbohydrates. Urea is manufactured commercially by combining ammonia and carbon dioxide under high pressure and temperature.

Urea is of nutritional value only to ruminants - cattle and sheep. Its utilization by these animals depends upon the conversion of urea nitrogen by the microorganisms of the rumen into bacterial protein that may be absorbed by the animal further on in the digestive tract. The rumen of the cow is a marvelous organ in which a great number of reactions occur; the conversion of non-protein nitrogen to bacterial protein is just one of them.

Urea is a valuable reserve feed to bridge the gap any time there is a shortage of protein feeds.

From an economic viewpoint, the greater the price differential between grains and protein concentrates, the greater the advantage of adding urea to rations for ruminants. Feeding trials have shown that 1 pound of urea plus 6 pounds of grain will replace about 7 pounds of 41 per cent oilseed meal.

1) WHAT IS UREA?

Urea in the pure form contains about 47% nitrogen. Urea feeding compounds contain substances to prevent caking, thus

are diluted to contain 42% nitrogen. There is no magic in urea. Urea does not contain trace minerals, vitamins, amino acids or protein, and it does not furnish energy.

2) HOW IS UREA USED BY RUMINANTS (CATTLE AND SHEEP)?

When eaten by cattle or other ruminants, urea goes to the paunch along with the other feeds. In the paunch the urea is changed chemically and liberates ammonia. The bacteria or "bugs" in the paunch use the nitrogen in the ammonia as a food for their growth and development. Bacteria are a low form of plant life which are able to use inorganic compounds like ammonia just as plants utilize chemical fertilizers. As these bacteria grow and multiply they make their body protein out of the nitrogen in the ammonia. Eventually the cow or sheep digests and absorbs the bacterial protein. Thus urea can be used to furnish part of the protein for ruminants.

3) IS UREA SUPERIOR TO OILSEED MEALS AS A SOURCE OF PROTEIN?

Experimental results to date do not show that urea is superior to the oilseed meals as a source of protein. When urea nitrogen is substituted for part of the oilseed meal nitrogen (protein) it dilutes the other nutrients. These nutrients must be supplied by adding them to the ration as supplements or by feeding additional feed. However, urea is usually used in such small amount that this effect is not serious.

4) DOES UREA STIMULATE THE ACTIVITY OF RUMEN BACTERIA MORE THAN THE OILSEED MEALS?

Experimental results to date do not show that urea has any greater stimulating effect on rumen bacteria than the oilseed meals.

5) THEN WHY FEED UREA?

Urea can serve to replace part of the protein nitrogen (oilseed meals) needed by ruminants. This is especially important when oilseed meals (protein concentrates) are in short supply or high in price.

6) HOW MUCH "PROTEIN" DOES UREA CONTAIN?

Urea does not contain protein. Urea is simply a source of nitrogen. The nitrogen (as ammonia) is converted to protein by rumen microorganisms. Urea feeding compounds contain about 42% nitrogen.

Protein = 16% nitrogen
$1.00 \div .16 = 6.25$
$6.25 \times$ nitrogen = protein equivalent

Thus nitrogen is converted to protein equivalent by multiplying by 6.25. One pound urea feeding compound contains 0.42 pound nitrogen, therefore $0.42 \times 6.25 = 2.62$ pounds of protein equivalent per pound of urea; or $2.62 \times 100 = 262$ per cent protein equivalent of urea. Since the oilseed meals supply nutrients other than nitrogen or protein such as energy and minerals the energy value displaced by urea must be made up with some other energy feed.

7) IS UREA POISONOUS?

Urea is not poisonous when properly mixed and fed in small amounts to ruminants. It is very important that urea be mixed thoroughly and uniformly with the feeds with which it is combined. Improper mixing or the use of excessive amounts can be dangerous.

8) HOW MUCH UREA SHOULD BE FED?

There does not seem to be a sharply defined limit, with regard to the maximum amount of urea which may be safely consumed by ruminants. It is definitely known that too much urea can be toxic and that urea is more efficiently and safely utilized when fed in small amounts, that is, less than 0.1 pound per animal daily. Apparently urea nitrogen is less efficiently utilized when fed in large amounts, that is, 0.25 pound or more per animal per day. Supplements containing more than 3 to 4 per cent urea should be fed with caution. Where large numbers of cattle (50, 100, 500 or more) are fed one or two pounds of protein supplement per head daily, as on the range, it is conceivable than certain agressive, hungry animals might rush in and consume 5 to 6 pounds of the supplement. This could lead to a consumption of a toxic level of urea.

For these reasons the following alternative limitations have been recommended for urea feeding:

1. One per cent urea by weight in the total dry matter of the feed consumed by cattle.

2. Fed at a level that will supply 1/3 (33%) by weight of the protein equivalent furnished by the grain fed, exclusive of the protein supplied by the roughage. (See TR-8,

Page 16 of the 1952 edition of the Association of American Feed Control Officials concerning the use of urea).

3. Du Pont in a Review of Nutrition Research on Urea as a Supplementary Source of Protein For Ruminants, - states, "The optimum amount of urea in any protein supplement for direct feeding is approximately 3%. No mixture to which an animal has access should contain more than 5% and the Association of American Feed Control Officials has recommended that mixtures carrying more than 3% be labeled with appropriate feeding instructions."

HOW MUCH UREA BY WEIGHT COULD BE FED TO ALL CLASSES OF CATTLE UNDER LIMITATION 1 ABOVE?

The following levels of dry matter consumption per head daily are taken from Recommended Nutrient Allowances for Beef Cattle - as published by the National Research Council. Daily level of urea feeding is shown in column 4. The crude protein equivalent is shown in column 5.

TABLE 1

Recommended Nutrient Allowances for Beef Cattle
(All feeds or rations are calculated on the basis of 90% dry matter)

Body wt. (pounds)	Daily feed per animal (pounds)	Daily dry matter intake per animal (calculated) (pounds)	Urea daily per animal (pound)	Crude protein equivalent furnished by this urea (pound)
Normal Growth, Heifers and Steers				
400	12	10.8	0.11	0.29
600	16	14.4	0.14	0.37
800	19	17.1	0.17	0.44
1000	21	18.9	0.19	0.50
Bulls, Growth and Maintenance (moderately active)				
600	16	14.4	0.14	0.37
800	18	16.2	0.16	0.42
1000	22	19.8	0.20	0.52
1200	24	21.6	0.22	0.58
1400	26	23.4	0.23	0.60
1600	26	23.4	0.23	0.60
1800	26	23.4	0.23	0.60

		Wintering Weanling Calves		
400	11	9.9	0.10	0.26
500	13	11.7	0.12	0.31
600	15	13.5	0.14	0.37
		Wintering Yearling Cattle		
600	16	14.4	0.14	0.37
700	17	15.3	0.15	0.39
800	18	16.2	0.16	0.42
900	18	16.2	0.16	0.42
		Wintering Pregnant Heifers		
700	20	18.0	0.18	0.47
800	20	18.0	0.18	0.47
900	18	16.2	0.16	0.42
1000	18	16.2	0.16	0.42
		Wintering Pregnant Cows		
800	22	19.8	0.20	0.52
900	20	18.0	0.18	0.47
1000	18	16.2	0.16	0.42
1100	18	16.2	0.16	0.42
1200	18	16.2	0.16	0.42
		Fattening Calves Finished As Short Yearlings		
400	12	10.8	0.11	0.29
500	14	12.6	0.13	0.34
600	16	14.4	0.14	0.37
700	18	16.2	0.16	0.42
800	20	18.0	0.18	0.47
900	21	18.9	0.19	0.50
		Fattening Yearling Cattle		
600	18	16.2	0.16	0.42
700	21	18.9	0.19	0.50
800	22	19.8	0.20	0.52
900	24	21.6	0.22	0.58
1000	26	23.4	0.23	0.60
1100	27	24.3	0.24	0.63
		Fattening Two-year-old Cattle		
800	24	21.6	0.22	0.58
900	26	23.4	0.23	0.60
1000	27	24.3	0.24	0.63
1100	29	26.1	0.26	0.68
1200	29	26.1	0.26	0.68

PROTEIN EQUIVALENT FURNISHED

Table 2

Pound urea feeding compound		Pounds protein* equivalent
.10	=	.26
.15	=	.39
.20	=	.52
.25	=	.66
.30	=	.79
.35	=	.92
.40	=	1.05
.45	=	1.18
.50	=	1.31
.55	=	1.44
.60	=	1.57
.65	=	1.70
.70	=	1.80
.75	=	1.96
.80	=	2.10
.85	=	2.23
.90	=	2.36
.95	=	2.49
1.00	=	2.62

* Calculated on basis of urea feeding compound containing 42% nitrogen or 262% protein equivalent.

Urea contained by supplements with different percentages of urea.

TABLE 3

Pounds of protein supplement	3	4	5	6	7	8	9	10
	pound urea in the supplement							
1	.03	.04	.05	.06	.07	.08	.09	.10
2	.06	.08	.10	.12	.14	.16	.18	.20
3	.09	.12	.15	.18	.21	.24	.27	.30
4	.12	.16	.20	.24	.28	.32	.36	.40
5	.15	.20	.25	.30	.35	.40	.45	.50
6	.18	.24	.30	.36	.42	.48	.54	.60
7	.21	.28	.35	.42	.49	.56	.63	.70
8	.24	.32	.40	.48	.56	.64	.72	.80
9	.27	.36	.45	.54	.63	.72	.81	.90
10	.30	.40	.50	.60	.70	.80	.90	1.00

The table's printed header reads "Per cent of urea in supplement" above the percentage columns.

The heavy line has been drawn to show the pounds of protein supplement that will furnish about 0.2 pound of urea. The figures below the line might be an excess of urea in some cases. To determine the amount of protein equivalent in any amount of urea multiply pounds of urea by 2.62.

Example:

How much crude protein equivalent is there in 0.03 pound urea:

2.62 x .03 = .0786

in 0.5 pound urea

2.62 x 0.5 = 1.310

Problem Example for Urea Feeding

A protein concentrate contains 5% urea. How many pounds of this could be fed to 700-pound yearling cattle on a full feed of grain, prairie hay and the protein supplement.

The first consideration when feeding a protein concentrate is -- How much protein is needed to balance this ration: These steers would need 1.4 pounds of digestible protein per head daily (National Research Council recommendation).

One pound of a feed containing 5% urea would furnish 0.05 pound urea.

See Table I, fattening yearling cattle. These steers could be fed 0.19 pound of urea per head daily.

0.19 ÷ .05 = 4, thus IF NEEDED to balance the ration four pounds of a protein supplement containing 5% urea could be fed. The steers would consume 20-21 pounds of feed daily per head, or:

14 pounds corn which contains about 0.92 pound digestible protein.

6 pounds prairie hay which contains about .13 pound digestible protein. The total digestible protein equals 1.05.

1.4 (needed) - 1.0 (furnished by corn and hay) = 0.4 to be furnished by the supplement. A supplement which contains 40% crude protein would contain about 32% digestible protein, therefore about 1.25 pounds would be needed to furnish the 0.40 pound needed to balance the ration.

Completed ration

14 pounds corn = 0.92 pound digestible protein.
6 pounds prairie hay = 0.13 pound digestible protein.
1.25 pounds of protein supplement = 0.40 pound digestible protein.

Total 1.45 pounds digestible protein

The 1.25 pounds is within the limits if the protein supplement contains no more than 5% urea.

Problem Example For Urea Feeding

A 40% protein supplement contains 5% urea. In this case 600-pound yearling cattle on a wintering ration are to be considered. These cattle would consume 16-18 pounds of feed (see table 1); or the following ration.

13 pounds prairie hay
4 pounds grain (corn)

They need about 0.8 pound of digestible protein per head daily. Prairie hay (fair to good quality) contains an average of about 5.7% crude protein, which is about 37% digestible. Thus 5.7 x .37 = 2.1% digestible protein. Therefore, 13 X .021 = .27 pound digestible protein in the prairie hay. Number 2 yellow dent corn contains an average of 6.6% digestible protein. Therefore, 4 X .066 = .264 pound. The digestible protein in the prairie hay (0.27 pound) plus the digestible prairie hay in the corn (0.26 pound) gives a total of .53 pound. These cattle as mentioned above need 0.8 pound of digestible protein, thus 0.80 - 0.53 = 0.27 pound to be supplied by the protein supplement.

On the average the protein in the usual cattle protein supplements is about 80% digestible: .40 x .80 = 0.3200 pound digestible protein per pound of 40% supplement. The steers are receiving 0.53 pound from the hay and corn, and one pound of the 40% supplement would furnish 0.32 pound of digestible protein. This makes a total of 0.85 pound. The 1 pound of supplement containing 5% urea would furnish .05 pound of urea. This is well within the limits.

1) Refer to table 1.
2) Find "Wintering Yearling Cattle."
3) Read right from 600-pound cattle to column 4, "Urea daily per animal," where the figure 0.14 pound is found. This is the amount of urea which can be fed daily per head to these cattle.
4) Now - refer to table 3.
5) Under "Per cent urea in supplement" find the column showing 5 per cent and read down.
6) This shows that 3 pounds of a supplement containing 5% urea would furnish 0.15 pound of urea, and 4 pounds of the urea-containing supplement would furnish 0.20 pound; therefore one could safely feed about 4.0 pounds of the supplement containing 5 per cent urea. However, as calculated above only 1 pound would be needed, thus the 1 pound could be safely fed.

Experimental tests have shown that supplements containing enough urea to furnish 25% or more of the protein equivalent are not as palatable as supplement containing less urea.

DOES UREA REQUIRE SPECIAL MINERAL SUPPLEMENTATION?

Urea utilization is dependent on bacterial action and bacteria require minerals for growth. However, recommended mineral allowances for the animal should also suffice for the bacteria in the rumen. A possible exception is the use of added sulfates.

WHAT RELATION HAS SULFUR TO UREA?

Protein contains about 1 part of sulfur to 16 parts of nitrogen, therefore sulfur should be added if the feeds with which urea is fed are low in sulfur. Present limited data on the sulfur content of feed make it difficult to know if the sulfur-nitrogen ratio will be adequate. Therefore, the use of sulfur with urea in the ratio of 1 part sulfur to 16 parts of nitrogen under the conditions as known at this time would appear to be useful until additional information is available. Sulfur can be supplied by adding ferrous sulfate at a level which will furnish 1 part of sulfur to 16 parts of nitrogen.

ARE HIGH ENERGY SUPPLEMENTS NECESSARY WITH UREA CONTAINING CONCENTRATES?

Bacteria require energy. They obtain energy from carbohydrate materials. Molasses and grains are typical examples of feedstuffs high in energy. Some feeding experiments have shown that there may be an advantage in including these high energy feeds in rations. Usual amounts suggested are 1/2 to 1 pound of molasses or 1 to 2 pounds of grain. If the ration contains one of these feeds in the suggested amount there would be no advantage in adding the other. It should be pointed out that some excellent results have been obtained with urea feeding using only 0.8 pound of corn with good quality hay. The inclusion of a small amount of molasses or corn can be regarded as a safety factor in insuring an adequate energy source for some urea nitrogen utilizing bacteria.