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LIMITATIONS OF
UREA AS A PROTEIN SUBSTITUTE IN THE RATIONS OF RUMINANTS

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I. R. Jones

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UREA AS A PROTEIN SUBSTITUTE IN THE RATIONS OF RUMINANTS

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I. R. Jones

Feeding standards for livestock give the minimum amounts of protein necessary for body maintenance, growth, and production. In feed-composition tables the nitrogen determined by chemical analysis is converted to protein by multiplying by the factor 6.25. In some plants, such as pasture grass, a considerable amount of nitrogen is present in non-protein form (amino acids and amids). It has long been realized that ruminants (cattle and sheep) can at least partially utilize the non-protein nitrogen of feeds, probably indirectly through a conversion to protein by means of microorganisms in the digestive tract.

Value of Simple Nitrogen Compounds, Such as Urea.

Inasmuch as the waste products of protein break-down, as eliminated in the urine of ruminants, include urea and ammonium salts, it has usually been considered that these compounds are of little value as a source of dietary nitrogen. Experiments previous to 1937, largely in Germany, were inconclusive in assigning feeding value for ruminants to non-protein nitrogen compounds such as urea, ammonium carbonate, and ammonium bicarbonate. The inconclusive results are now considered to be due to the shortness of the feeding trials and the high level of protein fed.

Recent carefully conducted experiments at several agricultural experiment stations in the United States and in England definitely show that ruminants can utilize simple nitrogen compounds, such as urea, as a source of nitrogen for body maintenance, growth, and milk production. Apparently, bacteria and protozoa growing in the rumen (paunch) can synthesize protein for their own use from the nitrogen in urea, and as the food passes into the stomach and intestines, the protein of these microorganisms is digested in the same manner as any other food protein. This idea receives confirmation from the fact that studies with ruminants have failed to show any significant differences in the biological value of protein from various plant and animal sources.

The fact that rumen microorganisms synthesize protein minimizes the necessity of supplying ruminants with feed containing all of the essential amino acids required for their body functions. From the standpoint of the practical feeding of cattle and sheep, this means that the quantity of nitrogen supplied is an important consideration; whereas, with non-ruminants, such as horses and pigs, and with poultry the quality of the protein (containing adequate amounts of essential amino acids), as well as the right amount, must be considered.

Limits to Urea Feeding

For the best results, some of the nitrogen required by ruminants must be fed in protein form, as there is undoubtedly considerable variation in the amount of protein that rumen microorganisms can synthesize. The character of the balance of the ration is probably important and requires further study. The usefulness of urea in the rations of the calf and lamb, with their relatively undeveloped rumen, likewise requires additional study. The amount of urea that can be fed is further limited by the fact that high levels are toxic, causing diuresis (excessive excretion of urine) and kidney lesions.

Urea has no value as a source of crude-protein equivalent in the rations of hogs, horses, chickens, and turkeys. Its use in proprietary feeds for these classes of animals is considered as adulteration.

What is Commercial Urea?

Urea is a white, crystalline, water-soluble organic compound, resembling salt in appearance. While it has been synthesized for more than 100 years, it has been made commercially in large quantities only in recent years. Urea contains about 46% nitrogen, or 287% (46 x 6.25) calculated protein. One of the urea products on the market at the present time contains a filler to prevent lumping so that the nitrogen present approximates 42%, or 262% calculated protein. In comparison, a high-protein concentrate, such as soybean meal, contains about 7% nitrogen, or about 44% calculated protein.

Amount of Urea that Can Be Safely Fed

Urea has been satisfactorily and safely fed to milk cows and growing heifers at the rate of 1% of the total dry matter of the ration, or 3% of the grain mixture, providing the grain mixture does not supply more than one-third of the total dry matter fed. If the level of grain feeding in a particular herd were high, for example, 20 pounds per cow daily, then 3% in the grain mixture would be near the toxic limit. It is our suggestion that not more than 1 to 2% of urea be added to the concentrate mixture in order to minimize the hazards of insufficient mixing, and the possible heavier-than-average grain feeding of the cows in dairy herds using the feed. Also, there is a loss of palatability in mixtures containing 3% urea.

Hazard in Feeding Urea Stressed

It should be stressed that urea will quickly kill livestock when fed in excessive amounts. This hazard in using urea should be realized by anyone contemplating adding it to a concentrate mixture. Several cases have been reported of animals being killed by consuming toxic quantities of urea. In case a dairyman is mixing his own feed, under no consideration should the urea be left where cattle might have access to it or where it might be mistaken for salt. Feed manufacturers using urea should give very definite instructions to employees on the amounts to be used, and should provide the added safeguard of pre-mixing definite percentage amounts with other concentrates in order to insure its even distribution in the feed. Additional experimental studies to determine the possible long-time effect on cattle of consuming amounts of urea that approach the toxic level are desirable.

Using Urea in Mixtures With Soybean Meal

Urease, an enzyme that splits off ammonia from urea, resulting in a loss of nitrogen, is found in some lots of soybean meal. Consequently, soybean meal that contains active urease should not be used in mixtures with urea. In most cases the manufacturer of the soybean meal will know whether or not it contains active urease. Its presence can be determined by mixing a small amount of soybean meal with urea, moistening with water, and allowing the mixture to stand over night in a closed container. If the odor of ammonia develops, active urease is present.

Economy of Using Urea

The use of urea in dairy-cattle rations will depend in part upon the economy with which it can replace high-protein concentrates. Under conditions of protein shortage, but with an adequate supply of farm grains, urea may find considerable use, even though its price is seemingly high. In experiments with dairy cows at the Wisconsin Agricultural Experiment Station, 2000 pounds of linseed oilmeal and 58 pounds of ground limestone were replaced in the ration by:

904 pounds ground corn,
904 pounds ground oats,
58 pounds bone meal,
113 pounds timothy hay,
250 pounds corn silage,
176 pounds urea (46% nitrogen).

In calculating the value of urea under Oregon conditions from the above amounts of feed, it is estimated that to replace one ton of linseed oilmeal in a concentrate mixture it would require:

1050 pounds ground oats,
900 pounds ground barley,
193 pounds urea (42% nitrogen),
50 pounds bone meal.

At a price per ton of \$50.00 for ground oats, \$54.00 for ground barley, \$80.00 for bone meal, and \$62.00 for linseed oilmeal, one could afford to pay about \$95.00 for urea (42% nitrogen). If the amounts of oats, barley, urea, and bone meal indicated above replaced one ton of soybean meal at \$64.00 per ton, the urea would likewise be worth about \$95.00 per ton.

It should be emphasized that urea is useful only for building up the nitrogen content of low protein feed mixtures. It cannot take the place of an abundance of palatable energy-producing feedstuffs. A poor ration can seldom be converted into a good one by merely adding urea.

Suggested Mixtures Containing Urea:

<u>Feed</u>	<u>Amounts</u> lbs	<u>Estimated</u>			
		<u>Crude Protein</u> lbs	<u>Fat</u> lbs	<u>Fiber</u> lbs	<u>Ash</u> lbs
<u>Mixture No. 1</u>					
Ground barley	250	23.8	5.0	15.0	6.5
Ground oats	250	24.0	13.8	28.8	9.3
Wheat Mixed Feed	350	54.3	14.0	29.8	17.5
Linseed oilmeal	120	39.8	7.0	10.8	6.6
Urea (42% N)	10	26.3	---	---	---
Bone Meal	10	0.7	0.3	0.1	8.1
Salt, iodized	10	---	---	---	10.0
	1000	168.9	40.1	84.5	58.0
	Percent	16.9	4.0	8.5	5.8

Mixture No. 2

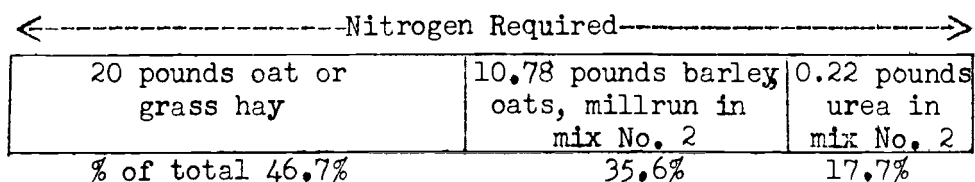
Ground barley	300	28.5	6.0	18.0	7.8
Ground oats	300	28.8	16.5	34.5	11.1
Wheat Mixed Feed	360	55.8	14.4	34.6	18.0
Urea (42% N)	20	52.5	---	---	---
Bone meal	10	0.7	0.3	0.1	8.1
Salt, iodized	10	---	---	---	10.0
	1000	166.3	37.2	87.2	55.0
	Percent	16.6	3.7	8.7	5.5

Mixture No. 3

Ground barley	290	27.6	5.8	17.5	7.5
Ground oats	300	28.8	16.5	34.5	11.1
Wheat Mixed Feed	300	46.5	12.0	25.5	15.0
Soybean meal	70	31.0	4.0	3.9	4.0
Urea (42% N)	20	52.5	---	---	---
Bone meal	10	0.7	0.3	0.1	8.1
Salt, iodized	10	---	---	---	10.0
	1000	187.1	38.6	81.5	55.7
	Percent	18.7	3.9	8.2	5.6

Example of Urea Usage

A 1000-pound cow producing 30 pounds of 4% milk daily requires 2.1 pounds of digestible protein and 17.7 pounds of total digestible nutrients. A daily ration consisting of 20 pounds of good-quality oat hay or grass hay and 11 pounds of any of the three suggested mixtures containing urea would meet this cow's feed requirement. If mixture No. 2 was fed, the nitrogen supplied by various ingredients in the ration are graphically shown below:



Sixteen pounds of mixture No. 2 without the urea would be required daily to meet this cow's nitrogen requirement.

Oregon Adopts Regulation on the Use of Urea

The Division of Foods and Dairies, Department of Agriculture, State of Oregon, has adopted the following regulation requiring the registration of urea and ammonium salts of carbonic acid, effective December 1, 1945:

"Regulation 4 of Administrative Order No. A. D. 234 became effective December 1, 1945.

"REGULATION 4. REGISTERING UREA AND AMMONIUM SALTS OF CARBONIC ACID

"Urea and ammonium salts of carbonic acid are acceptable ingredients in commercial feeding stuffs for cattle, sheep and goat feeds only; these materials shall be considered to be adulterants in commercial feeding stuffs for other animals and birds including poultry, except as herein specified. The total amount of urea present in any commercial feeding stuffs for cattle, sheep and goats shall not be more than 3% of the grain ration. The following statement of guarantee of crude protein for feeds containing these materials shall be used:

Crude protein, not less than _____%.
This includes not more than _____% equivalent
crude protein from non-protein nitrogen.

"This regulation is not intended to prevent the use of urea in poultry feeds where it is included with other materials as a claimed aid for the mitigation of poultry diseases. No consideration is to be given to this added urea in the formulation of protein guarantees. Each package of poultry feed containing urea shall have attached to it a separate label reading as follows:

"This feed contains urea for a claimed treatment and preventive of coccidiosis. The nitrogen content of urea is not included in the protein guarantee."

"Done in the office of the Department of Agriculture, State of Oregon, this 10th day of October, 1945.

O. K. BEALS, Chief
Division of Foods and Dairies

E. L. PETERSON, Director
Department of Agriculture"

Recent Publications on Urea Feeding

- (1) Urea as a Protein Substitute in the Diet of Young Cattle. S. Bartlett and A. G. Cotton. Jour. Dairy Research (England), Vol. 9, pp. 263-272, 1938.
- (2) The Utilization of Simple Nitrogenous Compounds Such as Urea and Sodium Bicarbonate by Growing Calves. E. B. Hart et al. (Wis.). Jour Dairy Sci., Vol. 22, pp. 785-798, 1939.
- (3) The Value of Urea as a Protein Supplement Replacement for Dairy Heifers. S. H. Work and L. A. Henke. Am. Soc. Animal Prod. Proc., Vol. 3, p. 404, 1939.
- (4) The Value of Urea in the Synthesis of Protein in the Paunch of the Ruminant. L. E. Harris and H. H. Mitchell (Ill.). Jour. Nutr., Vol. 22, p. 167, 183, 1941.
- (5) The Utilization of Urea by Ruminants as Influenced by the Level of Protein in the Ration. M. I. Wegner et al. (Wis.). Jour. Dairy Sci., Vol. 24, p. 825, 1941.
- (6) Synthetic Urea Proves Satisfactory in Dairy Rations. Rep. Chief, Bureau Dairy Ind., U.S.D.A., p. 210, 1941.
- (7) The Relative Efficiency of Urea as a Protein Substitute in the Rations of Ruminants. B. C. Johnson et al. (Ill.). Jour. Animal Sci. Vol. 1, pp. 236-245, 1942.
- (8) The Utilization of Urea by Ruminants as Influenced by the Presence of Starch in the Ration. R. C. Mills et al. (Wis.). Jour. Dairy Sci., Vol. 25, pp. 925-929, 1942.
- (9) Feeding Urea to Dairy Cows. J. H. Archibald. Mass. Agric. Experiment Station Bul. 406, 1943.
- (10) The Utilization of Urea in the Bovine Rumen. R. M. Pearson and J. A. B. Smith. (England). Biochem. Jour., Vol. 37, pp. 142-164, 1943.
- (11) The Comparative Value of Urea and Linseed Meal for Milk Production. I. W. Rupel et al. (Wis.). Jour. Dairy Sci., Vol. 26, pp. 647-664, 1943.
- (12) On the Mechanism of Non-Protein Nitrogen Utilization by Ruminants. B. C. Johnson et al. (Ill.). Jour. Animal Sci., Vol. 3, pp. 287-298, 1944.
- (13) Utilization of Urea and Growth of Heifer Calves with Corn Molasses or Cane Molasses as the Only Readily Available Carbohydrate in the Ration. R. C. Mills et al. (Wis.). Jour. Dairy Sci., Vol. 27, pp. 571-578, 1944.
- (14) The Use of Urea in Commercial Dairy Feeds. W. H. Hastings. Jour. Dairy Sci., Vol. 27, pp. 647-648, 1944.
- (15) Corn Silage Made With Addition of Urea. T. W. Woodward and J. B. Shepherd (U.S.D.A.). Jour. Dairy Sci., Vol. 27, pp. 648-649, 1944.
- (16) Urea in Sorghum Silage. G. K. Davis et al. (Fla.). Jour. Dairy Sci., Vol. 27, p. 649, 1944.
- (17) Urea-Treated Corn Silage vs. Untreated Corn Silage as a Feed for Lactating Dairy Cows, G. H. Wise et al. (S.C.). Jour. Dairy Sci., Vol. 27, pp. 649-650, 1944.