Urea in Ruminant Nutrition

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Story in Brief

Protein is one of the most important nutrients in the nutrition of man and his domestic and wild animals. Thus, it behooves him to use protein judiciously and to utilize substitutes whenever possible.

Urea can be made from the products of air and many workers have shown that urea plus grain may be used to replace vegetable protein supplements in beef, dairy and sheep rations providing the level of grain is high. Tillman (1)[1] has discussed in some detail how ruminants utilize urea and the reader is referred to this article for this background information. The purpose of this paper is to discuss the using of urea in the rations of beef cattle.

Introduction

Most beef fattening rations contain urea. The compound is mixed with other feeds to formulate a premix, which contains a high level of urea, minerals, vitamins, and other items considered important by the feeder such as antibiotics and stilbestrol. The premix is then mixed with other feeds in a mobile mixer while the feed is enroute from the weighing area to the feed bunk. Examples of such mixtures are shown in Table 1 (2,3). Urea consumption under these conditions will be from 0.15 to 0.20 lb./day, representing a protein potential of 0.4 to 0.5 lb.

Table 1. Percentage Composition of Premixes[1] for Beef Cattle Feeding.

Rations	Purdue 64	Iowa 80
Dried molasses	----	33.0
Cane molasses	14.0	----
Alfalfa meal	51.0	----
Bone meal	10.4	----
Iodized salt	3.5	----
$CaHPO_4$	----	20.0
$CaCo_3$	----	12.0
Trace minerals	----	1.0
Stilbestrol premix	----	2.0
Vitamin A mix	----	2.0
Urea	21.1	30.0
Total	100.0	100.0

[1] Beeson *et al.* (2)
[2] Burroughs *et al.* (3)

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[1] Numbers in parentheses are references which appear at the end of the article.

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Urea has been used in "all concentrate" diets and an example is shown in Table 2. It will produce results comparable to the vegetable protein supplements as was shown in North Carolina studies (4). Oklahoma studies (5) are shown in Tables 3 and 4 in which milo was the grain. One-hundred and ten steers were used in these trials and treatments did not affect ($P<.05$) animal performance; however it will be noted that rations containing urea produced greater financial returns than those containing the vegetable protein supplement. An interesting aspect of this study concerns the improvement obtained by adding alfalfa meal to the urea-containing ration even though the mineral content of that ration met requirements as set forth by the National Research Council. Other workers have also found that alfalfa hay improved similar rations.

Results and Discussion

In general, it may be considered that 7 lb of milo plus 1 lb. of urea (45 percent N) will be isonitrogenous with 8 lb. of a vegetable protein supplement. If urea sells for 4 cents, milo 2 cents and cottonseed meal 4 cents/lb. the following calculations are relevant to the economics of urea utilization in fattening rations:

Table 2. Percentage Composition of an All-Concentrate Diet for Beef Cattle.[1]

Ingredient		Percent
Ground shelled corn		95.1
Urea		1.0
Cottonseed oil		2.0
NaCl		0.5
$CaCO_3$		0.7
Defluorinated phosphate		0.2
Trace minerals		0.4
Vitamin A & D		0.1
	Total	100.0

[1] Wise *et al.* (4)

Table 3. Percentage Composition or the Diets[1]

	Diets				
Ingredients	1	2	3	4	5
Ground milo	87.50	84.75	96.25	91.50	87.70
Dehydrated alfalfa	----	5.00	----	5.00	5.00
Cottonseed meal	8.10	7.00	----	----	3.20
Urea[1]	----	----	0.96	0.84	0.46
Premix	4.40	3.25	2.77	2.66	3.59
Total	100.00	100.00	100.00	100.00	100.00

[1] McCartor and Tillman (5)

Table 4. Feedlot Performance of Steers (143 Day-Test)[1]

Item	CSM[2]	CSM+D[3]	Urea(u)[2]	U+D	CSM+U+D
Animal, Nos.	23	21	23	22	18
Final weight, lb.	1070	1050	1055	1066	1056
Initial weight, lb.	716	714	714	722	721
Daily gain, lb.	2.48	2.35	2.38	2.40	2.34
Daily feed, lb.	19.99	19.72	19.77	19.83	19.53
Feed/lb. gain, lb.	8.06	8.39	8.31	8.23	8.35
Final value-dollars[4]	273.00	268.00	269.00	272.00	269.00
Initial value-dollars	200.00	199.50	199.50	202.00	202.00
Increase-dollars	73.00	68.50	69.50	70.00	67.00
Feed cost-dollars[5]	66.92	60.06	55.99	55.02	55.50
Return over feed-dollars	6.08	8.44	13.51	14.98	11.60

[1] McCartor and Tillman (5)
[2] CSM=Cottonseed meal
[3] D=Dehydrated alfalfa meal
[4] Appraisals used for initial and final values.
[5] Actual feed cost only.

Cost of protein from cottonseed meal will be 8 X 4 = 32 cents.
Cost of protein from urea + grain:

Urea	1 X 4 =	4 cts.
Grain	7 X 2 =	14 cts.
Total		18 cts.

The costs of 18 vs. 32 cents for 8 lb. of feed, is significant, and is of course, reflected in the financial statement of the Oklahoma results.

The major problem in beef cattle nutrition concerns the poor utilization of urea by mature cows allowed to graze low-protein forages during the winter season. Such forages are, of course low in protein, phosphorus, certain trace minerals, and available energy. Vegetable protein supplements, such as cottonseed meal and soybean meal, have always found wide usage as supplements when cattle are allowed to graze these forages during the winter season. As there is great demand for the vegetable protein supplements for feeding of poultry and swine, and even in human nutrition, the price per unit of nitrogen is higher for these products as compared to urea-grain mixtures; therefore, economics dictate the usage of urea in range supplements.

Early Oklahoma research (6) indicated that urea could be used in range supplements if the level of urea in the mixture was low. However, in later Oklahoma studies involving 16 tests using 879 cattle in which urea supplied one-third of nitrogen in the supplements which were isonitrogenous with cottonseed meal, it was found (7) that animal performance was always lower on the urea supplements even though the urea containing supplements were always improved by addition of trace minerals or alfalfa meal. Many feedmen and applied nutritionists often forget that urea is a pure compound and that it replaces a vegetable protein supplement, which contains phosphorous, trace minerals, and energy. Urea must be fed in balanced rations for good results.

Another factor to consider in urea utilization on the range concerns the amount of energy in the supplement. Oklahoma results (8) indicate that the supplement should contain a N.F.E.:N ratio of at least 30:1 and that urea-containing rations, in which grain is the carrier should not contain over 2 percent urea. Higher levels of urea produce poorer results than when vegetable protein sources are the control rations.

Berry *et al.* (9) fed range cattle a liquid mixture compound of cane molasses, urea, phosphoric acid, trace minerals and vitamin A. The supplement contained about 10 percent urea and the phosphoric acid content was varied so as to regulate intake when the mixture was fed free choice. It is believed that the slow rate of intake improved urea utilization but definitive experiments have not been conducted. Because of their labor saving potential, liquid supplements are finding increasing interest and use in Oklahoma. In most of these supplements, intake is also limited by mechanical means. If labor is not a factor, the liquid supplements, during most years, cannot compare economically with vegetable protein supplements or with supplements containing grain plus urea. Molasses are lower in energy and are a more expensive source of energy as compared to milo. The liquid supplements must be protected from rain or toxicity will result; water will dissolve the urea and the animal will drink this in the absence of a carbohydrate source.

A major difficulty of feeding urea supplements concerns possibility of urea toxicity. Oklahoma workers (10) have studied in detail urea toxicity symptoms and these are as follows:

1. From 30 to 60 minutes after ingesting urea, steers showed uneasiness, staggering and kicking at the flanks.
2. These symptoms were followed by more serious incoordination, tetany and finally prostration.
3. These animals went down within 30 to 60 minutes after dosing. While prostrate, the most pronounced symptoms of distress were severe convulsions, slobbering at the mouth and bloating.
4. Ammonia levels of rumen contents were high. This was quickly followed by high ammonia levels in peripheral blood.
5. Blood urea levels were high but cannot be taken as an indicator of severity of toxicity. When tetany begins, blood urea levels begin to drop.
6. Bloating was always present and the rumen contents had pH readings consistently above 8.0.

7. The amount of urea necessary to produce toxicity was about 14 grams per 100 lb. body weight.
8. All animals were dead within one to three hours after dosing.

Florida workers (11) repeated and extended the Oklahoma experiment and found that acetic acid, if administered prior to the onset of tetany, would alleviate toxicity symptoms. It required 2 moles of acetic acid for each mole of urea consumed. For example, a 1000 lb. cow required about 140 gm. of urea to cause toxicity. It would require 280 gm. of pure acetic acid to neutralize the amomnia liberated by catalysis of the urea. Since concentrated acetic acid would cause phosiological harm to the animal, it is diluted to a 5 percent v/v solution and pumped directly into the rumen. If the 280 gm. of acetic acid needed is converted to volume of 5 percent solution, it is found that 4600 ml. are needed. As vinegar contains about 5 percent acetic acid, about one and one-half to two gallons of vinegar would be just as effective.

Later Oklahoma work indicated (12) that a second dose of acetic acid or vinegar given about 160-170 min. after the first prevents reappearance of urea toxicity symptoms. The second dose should be one-half as much as the first dose, about one gallon of vinegar.

Oklahoma workers (13) conducted further research on feeding conditions which might cause urea toxicity and their results indicate that there are predisposing factors which increase the susceptibility of cattle and sheep to urea toxicity. These are as follows:

1. Animals which have never consumed urea appear to be the most susceptible.
2. Animals which have previously been consuming only low-nitrogen roughages and are in a semi-starved condition will consume urea-containing feed rapidly.
3. Individual animals within the herd which are aggressive and consume their feed rapidly are more susceptible. In many cases where urea toxicity in the field has occurred, the rancher reports that his best animals were the victims.
4. Animals which have had previous access to urea-containing feeds will consume the diet slowly and will not consume enough urea to cause toxicity. In Oklahoma studies, sheep weighing 75 lb. have consumed over 80 grams of urea per day but consumption was slow; the animals simply nibble the feed and spend much more time at the feed trough. Also cattle weighing 500 lb. consumed in a similar manner over 400 grams of urea with no toxicity symptoms becoming apparent.

Oklahoma workers (12) produced urea toxicity symptoms in pregnant cows by drenching at two stages in the gestation cycle, 90 days and 4½ months after breeding. When toxicity symptoms became apparent

(15 min. after urea administration), 5 percent acetic acid was pumped via stomach pump directly into the rumen; the urea: acetic molar ratio was 2:1. After an elapse of 165 min., acetic acid at a urea: acetic ratio of 1:1, was administered as before.

Rumen fluid and blood ammonia levels were high in all treated cows at the time of acetic acid administration and urea toxicity symptoms were apparent. In fact, several animals died in spite of all precautions. When acetic acid was administered rumen fluid blood ammonia levels dropped quickly and the cows showed no signs of distress. All cows, which recovered, completed the normal term of pregnancy and produced normal calves. Subsequent breeding performance was as good as that obtained in the controls. Thus it appears that if pregnant cows recover from urea toxicity symptoms that reproductive performance is not affected.

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