LEVEL OF UREA IN HIGH GRAIN DIETS: NUTRIENT DIGESTIBILITY, MICROBIAL PROTEIN PRODUCTION, AND RUMEN METABOLISM [1]

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Summary

Four ruminally and duodenally fistulated steers (1228 lb) were used in a 4 × 4 Latin square design to evaluate the effects of dietary urea level on nutrient digestion, microbial protein production, and rumen metabolism of steers fed a rolled corn diet without urea or with .5, 1.0, or 1.5% urea (dry matter basis) and no other supplemental protein. Rumen digestibilities increased 33% for organic matter and 25% for starch with the first increment (.5%) of urea, but little or no improvement occurred with subsequent urea additions. Apparent rumen nitrogen digestibility decreased linearly, whereas total tract and true ruminal nitrogen digestibility increased linearly with increased urea. Duodenal nitrogen flow and microbial protein production were not affected by treatment. Rumen pH decreased and total volatile fatty acids increased as dietary level of urea increased. Molar proportions of propionate increased and butyrate decreased linearly with the addition of urea, suggesting increased efficiency of rumen fermentation. Rumen NH_3 increased 63% following 1.0% urea addition to the diet. Urea improved ruminal digestibility and increased efficiency of fermentation but did not increase metabolizable protein to the small intestine.

(Key Words: Urea, Digestibility, Rumen, Steers.)

Introduction

Current information regarding the requirements by finishing steers for rumen degradable nitrogen and metabolizable protein remains limited. In order to establish metabolizable or net protein systems, rumen degradable protein requirements are needed. Urea is a common source of rumen degradable nitrogen in finishing diets. Therefore, the objective of this study was to evaluate the effects of dietary level of urea on nutrient digestion, microbial protein production, and rumen metabolism.

Experimental Procedures

Four ruminally and duodenally fistulated crossbred steers (1228 lb) were used in a 4 × 4 Latin square design to evaluate the effects of dietary urea level on nutrient digestibility and ruminal metabolism. Diets (Table 1) contained no urea or .5, 1.0, or 1.5% urea (dry matter basis) and no other supplemental protein. Steers were fed ad libitum twice daily. Chromic oxide was used as an indigestible flow marker. Each period consisted of a 10-day diet adaptation and a 4-day sample collection period. During the collection period, duodenal digesta and fecal grab samples were collected four times daily to determine ruminal and total tract digestibilities of organic matter, starch, and nitrogen. Rumen fluid was collected at 3, 6, 9, and 12 hours after the a.m. feeding and analyzed for pH, volatile fatty acids, and ammonia. Rumen contents were harvested

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twice daily for 2 days to determine microbial protein production.

Results and Discussion

Dry matter intake as a percent of body weight responded cubically to the addition of urea (Table 2). Ruminal organic matter and starch digestibilities tended (P=.23) to respond quadratically to the addition of urea. Both ruminal organic matter and starch were improved by the first increment of urea (.5%), with little or no improvement by subsequent additions. Pooled across level, urea increased ruminal digestibility of organic matter by 26% and starch by 25%, compared to the control diet. Average total tract digestibilities of organic matter were 76%, 87% for starch and were similar (P>.25) among treatments. Apparent rumen nitrogen digestibility increased (P<.07) linearly as level of urea increased. Nitrogen flowing from the rumen with the control diet was 182% of nitrogen intake, which indicates that a vast amount of nitrogen recycling was occurring. Total tract (P<.02) and true ruminal nitrogen (P<.10) digestibilities increased linearly as dietary level of urea increased. Duodenal ammonia nitrogen flow tended (P=.16) to respond quadratically to urea level. Duodenal nitrogen flow, microbial protein production, and microbial efficiency (g of microbial N/100g of organic matter fermented) were not affected (P>.24) by treatment. Rumen pH decreased (P<.01) and total volatile fatty acid concentration increased (P<.01) linearly with increasing urea, suggesting that supplemental urea enhanced organic matter fermentation. Molar proportion of propionate tended (P=.11) to increase, whereas that of butyrate decreased (P<.01) linearly with increasing urea, suggesting that fermentation efficiency was increased. Molar percent acetate responded cubically (P<.01) to the addition of urea. The increased molar percentage of acetate with the .5% urea diet was responsible for most of the cubic effect; other treatments varied little. Acetate:propionate ratios were not affected by dietary urea level. Rumen NH_3 concentration responded cubically (P<.01) to urea additions. Little increase was observed with the first increment of urea (.5%); however, 1.0% urea increased rumen NH_3 63%, with little further increase at 1.5%. The addition of urea improved rumen digestibility of organic matter and starch, increased nitrogen digestibility, and enhanced efficiency of rumen fermentation but did not increase the amount of microbial protein available to the animal. These results suggest that urea addition improved energy utilization by the animal but did not improve metabolizable protein supply to the small intestine. Levels of urea near .5% of the diet appear to be sufficient for optimal rumen digestibility and fermentation efficiency.

Table 1. Diet Composition [a]

	Treatment (% Urea, dry matter basis)			
Ingredient	Control	.5	1.0	1.5
Rolled corn	76.9	77.0	77.2	77.2
Prairie hay	10.0	10.0	10.0	10.0
Supplement 1 [b]	10.6	7.1	3.5	--
Supplement 2 [c]	--	3.4	6.8	10.3
Molasses	2.5	2.5	2.5	2.5
% Crude protein (dry matter basis)	7.7	9.0	10.3	11.6

[a]Dry matter basis. Formulated to supply .7% Ca, .35% P, .7% K, 25 g/ton Rumensin, and 10 g/ton Tylosin. Elemental sulfur was supplied to maintain N:S ratio of 10:1 for all diets. [b]Supplement supplied no urea. [c]Supplement supplied 1.5% dietary urea (dry matter basis) in 1.5 treatment.

Table 2. Effect of Urea Level on Nutrient Digestibility, Microbial Protein Production and Rumen Metabolism

	Treatment (% Urea, dry matter basis)				
Item	Control	.5	1.0	1.5	SEM
Dry matter intake[a], % BW	2.52	2.59	2.15	2.43	.12
Nitrogen intake, g/d	171	205	189	234	9.27
Apparent rumen digestibility, % of intake					
Organic matter	25.3	43.2	36.9	34.3	7.04
Starch	47.1	64.6	59.2	63.7	7.48
Nitrogen[b]	-82.9	-28.1	-37.3	-17.9	11.4
True rumen digestibility, % of intake					
Organic matter	45.6	57.2	55.8	51.6	7.49
Nitrogen[b]	3.7	32.9	33.4	46.7	14.8
Total tract digestibility, % of intake					
Organic matter	74.9	73.9	82.5	75.2	3.74
Starch	84.8	85.2	93.5	87.2	3.80
Nitrogen[c]	55.9	58.4	70.8	67.2	4.40
Duodenal N flow, g/d	321	264	267	291	27.2
Microbial N flow, g/d	146	125	141	153	14.01
Duodenal NH_3-N, g/d	17.6	22.4	29.2	19.6	4.51
Microbial efficiency[d]	2.93	1.75	2.38	4.08	1.13
Rumen pH[e]	6.00	6.06	5.81	5.74	.08
Rumen NH_3[f], mM	2.16	3.07	8.40	9.13	.69
Total VFA[e], mM	113	109	127	133	4.22
Acetate, molar %	44.7	47.1	43.1	44.8	.88
Propionate, molar %	27.3	28.0	29.6	30.3	1.46
Acetate:Propionate ratio	1.78	1.92	1.61	1.68	.14
Butyrate[e], molar %	16.4	12.3	11.2	9.9	1.21

[a]Cubic ($P<.07$).

[b]Linear ($P<.10$).

[c]Linear ($P<.02$).

[d]Grams of microbial N/100g of organic matter truly fermented in the rumen.

[e]Linear ($P<.01$).

[f]Cubic ($P<.01$).