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Urea Utilization by Cattle Fed Prairie Hay and Supplemented with Zinc

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Story in Brief

Six 825 lb heifers were fed prairie hay and urea (45 and 90 g urea/animal/day) in two 3 x 3 Latin squares; three Zn levels were assigned within each square, with zinc chloride added at either 30 (ZN1- dietary requirement), 250 (ZN2) or 470 (ZN3) ppm of Zn in diet DM. The urea plus mineral supplements were dosed via rumen cannula once daily. After 7 d of adaptation, the rumen was sampled frequently on day 8; intake of prairie hay was measured on days 9 to 16. Responses in ruminal pH and NH_3 to urea and Zn levels differed with time. In general, pH was lower during the 12 to 24 h period than during the first 2 to 6 h period (6.68 vs 6.98). Concentrations of NH_3, highest for all treatments at 2 h (56, 43 and 35 mg/dL for ZN1, ZN2 and ZN3), were decreased by added Zn. Such a reduction may diminish the risk of urea toxicity. Rumen NH_3 concentrations decreased over time in a similar fashion for all Zn treatments. Ammonia concentrations over time differed between ZN1 vs ZN3. If 5 mg/dL is accepted as the minimum concentration needed for optimal rumen fermentation rate and microbial activity, values fell below this level sooner with ZN1 than ZN3 (8.9 vs 13.4 h). Digestible dry matter intake tended to be lower at the highest Zn level (ZN1= 5.64, ZN2= 4.98 and ZN3= 4.45 lb/animal/daily, respectively). The longer time period at higher NH_3 concentration should favor Zn supplementation.

(Key Words: Urea Utilization, Zinc, Cattle.)

Introduction

Urea is an economical protein source for ruminants, and widely used because of its convenience, availability, and low cost. Although urea is frequently used in high concentrate feedlot rations, its potential should be even greater with poor quality, low protein diets. Urea provides NH_3 to the rumen that can be used for microbial protein synthesis. Increasing microbial protein yield in the rumen should increase digestibility and feed intake.

When urea is converted to NH_3 into the rumen too rapidly, incorporation of NH_3 into microbial cells is inefficient; excess of NH_3 is absorbed, converted into urea by the liver, and excreted. Excess NH_3 in the blood can cause toxicity. A shortage of carbon skeletons, such as in low quality forages, may also limit microbial protein synthesis.

By avoiding spikes of NH_3 in the rumen reducing the rate of ammonia release may improve the usefulness of urea. Several minerals can influence NH_3 production rate. High amounts of Zn or Zn plus Mn have improved urea utilization, N balance, and weight gain by sheep (Rodriguez et al., 1995). Additionally, supplementing with 860 ppm Zn significantly decreased rate of NH_3 production (Arelovich et al., 1997). Our objective was to assess the effect of supplemental Zn on ruminal metabolism and digestion of prairie hay.

Materials and Methods

Six ruminally cannulated heifers with an average weight of 825 lb were fed prairie hay (PHAY) and urea (45 or 90 g urea/animal/daily) in two 3 x 3 Latin squares. Medium quality PHAY, fed at 10.7 lb of DM split in two daily meals, was supplemented with either 30 (ZN1), 250 (ZN2) or 470 (ZN3) ppm dietary Zn from Zn chloride; additionally, Mn chloride was included in all diets to provide 40 ppm of Mn. These levels were designed to meet the Zn requirement (ZN1), provide a level estimated to be the maximum tolerated level (ZN3), and one intermediate level (ZN2). Ruminal pH and NH_3 concentrations, DM intake (DMI), DM digestibility (DMD) and digestible DMI (DDMI) were determined.

The pH of ruminal fluid was measured immediately after sampling. A 100 ml subsample was acidified with sulfuric acid and frozen. When thawed later, it was centrifuged for 10 min at 16,000 x g and analyzed for NH_3. Prairie hay, orts, and fecal samples were dried and analyzed for dry matter and ash.

Means were compared statistically using a T test; orthogonal contrasts were used to compare treatment means for the early (2 to 6 h) vs the late (12 to 24 h) periods after urea dosing. Regression of NH_3 concentration against time was also employed to test treatment effects.

Results and Discussion

Neither urea nor Zn levels significantly affected DMI or DMD (Table 1), although DDMI at the highest Zn level tended to be reduced as a result of slightly reduced digestibility. At high Zn concentrations, activities of rumen microbes may be reduced. In a previous study (Arelovich et al., 1997) similar effects were detected. DMI by animals were given free choice access to feed averaged 10.9 lb or 1.32% of the average body weight.

Response of rumen pH and NH_3 to Zn levels differed with time (Table 2), with an interaction between Zn and time in both pH (P=.049) and NH_3 (P=.066). The pH was higher during the early (2 to 6 h) than the later (12 to 24 h) period (6.98 vs 6.68; P=.0001) after dosing urea. This pH drop probably did not affect the rumen environment enough to decrease in cellulose and fiber digestion. The high pH values probably reflect the basic nature of NH_3 liberated from urea. Higher concentrations of NH_3, early after the supplement was fed, were likely followed by greater volatile fatty acid production.

Concentrations of NH_3 were decreased (P=.0001) by added Zn 2 h after feeding (56, 43 and 35 mg/dL for ZN1, ZN2 and ZN3, respectively). Rumen NH_3 concentrations decreased similarly for all Zn treatments over time being higher from 2 to 6 h than 12 to 24 h (P=.0001).

The Zn x time interaction was best described by a cubic regression as shown in Figure 1. Regression analysis revealed a significant difference in the NH_3 concentration pattern between ZN1 and ZN3 (P=.039). A minimum of 5 mg/dl is suggested to be needed for optimal activity of ruminal bacteria. Concentrations fell below this level sooner with ZN1 than ZN3 (8.9 vs 13.4 h). These results favored Zn supplements. Additionally, as shown in Figure 1, NH_3 concentration at 2 h was reduced by Zn addition. Such changes should improve efficiency of urea utilization and decrease the risk of toxicity among ruminants fed supplements containing a large amount of urea.

Literature Cited

Arelovich, H.M. et al. 1997. Okla. Agr. Exp. Sta. Res. Rep. P-958:103.

Rodriguez, B.T. et al. 1995. Ann. Zootech. 44 (Suppl.1):229.

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Table 1. Prairie hay dry matter intake and digestibility in heifers receiving different levels of urea and Zn.

	Urea level		Zinc level		
Item	U1	U2	ZN1	ZN2	ZN3
Dry matter intake lb/d	10.77	10.99	11.59	10.20	10.84
Dry matter digestibility %	47.11	46.49	48.48	49.11	42.82
Digestible DM intake lb/d	5.07	4.98	5.64	4.98	4.45

Table 2. Ruminal pH and N-NH3 concentrations in fistulated heifers consuming prairie hay and receiving different levels of added Zn, averaged across the two levels of supplemental urea.

	Time, h						
Item	2	4	6	12	18	21	24
pH[1]							
ZN1	7.18[a]	7.03	6.77	6.52	6.71	6.82	6.68
ZN2	6.95[ab]	7.19	6.87	6.58	6.70	6.72	6.63
ZN3	6.87[b]	7.03	6.95	6.66	6.69	6.77	6.71
$N\text{-}NH_3$[1]							
ZN1	55.96[a]	34.44	15.46	2.36	1.38	2.23	1.21
ZN2	43.35[ab]	42.29	22.31	2.87	1.30	1.77	1.23
ZN3	34.85[b]	33.94	20.89	5.42	1.13	1.73	.83

[1]Zn by time interaction detected (P=.049) and (P=.066) for pH and $N\text{-}NH_3$, respectively.

[a,b,c] Values within a measurement with different superscripts differ (P<.05)

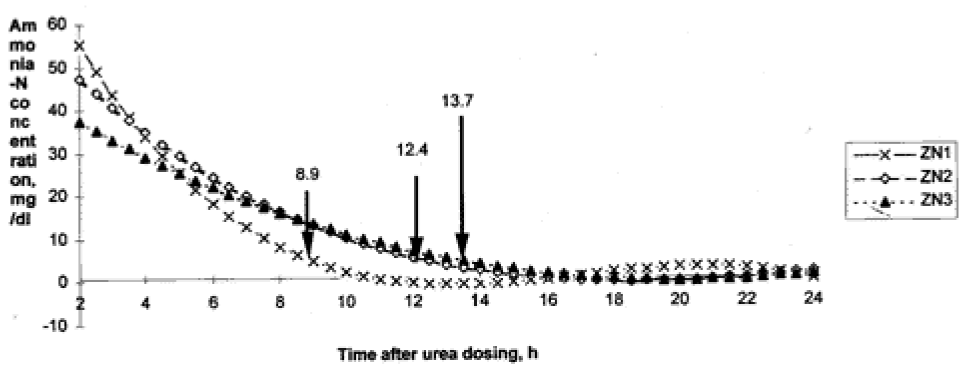

Figure 1. Relationship between rumen $N\text{-}NH_3$ concentration and time elapsed after supplements were fed.

ZN1 : NH_3 = -.011969227 hr^3 + 1.00398031 hr^2 - 16.23196109 h + 83.88959551 R^2= .9929

ZN2 : NH_3 = -.00415955 hr^3 + .33474395 hr^2 - 8.13704005 h + 62.26730734 R^2= .9611

ZN3 : NH_3 = -.00079828 hr^3 + .1467320 hr^2 - 4.93607014 h + 46.68630598 R^2= .9749

ZN1 vs ZN3 P= .0394

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