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Effect of Dietary Cation-Anion Difference on Intake and Urinary pH in High Concentrate Diets

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Summary

Seven experiments evaluated the effect of basal diet and dietary cation-anion difference (DCAD) on urinary and fecal pH, and DMI. Dry-matter intake (DMI) was reduced by DCAD level in dry-rolled corn basal diets but not in diets that included 20% wet distillers grains (WDGS). Urinary pH decreased with DCAD level in all experiments. Fecal pH was not influenced by either DCAD level or basal diet. Altering DCAD in concentrate diets with or without WDGS does impact urinary pH.

Introduction

Nitrogen loss may be reduced by shifting the equilibrium from NH_3 to NH_4 by acidification of cattle waste. The majority (60-80%) of N excreted by feedlot cattle is in the urine. Lowering urinary pH may reduce the amount of ammonia volatilized by shifting a greater proportion of N into the ammonium form. One way to reduce urinary pH is by lowering the dietary cation-anion difference (DCAD). Dietary cation-anion differences can be changed to induce metabolic acidosis, which aids in calcium homeostasis at the onset of lactation (Goff et al., 2004, *Journal of Dairy Science*). Lowering DCAD has an impact on animal performance, blood pH, and urine pH. If urine and pen surface pH can be lowered by altering DCAD in concentrate diets, N losses may be reduced. The objective of these experiments was to determine the influence of basal diet and DCAD level on urinary and fecal pH and DMI.

Procedure

Lambs

Fifteen wether lambs (75 ± 7 lb) were used in five consecutive 3 x 3 Latin squares. Basal diets consisted of 82.5% dry-rolled corn (DRC), 7.5% alfalfa hay, 5% molasses and 5% supplement (DM). Dietary cation-anion difference was calculated as milliequivalents (mEq) of [(Na + K) – (Cl + S)] per 100 g of feed DM. Ammonium chloride, ammonium sulfate and calcium chloride were used to lower DCAD to 0, -8, -16, -24 and -45 mEq, replacing urea, fine ground corn and limestone. Sodium bicarbonate and potassium carbonate were used to increase DCAD to +16, +24, +32 and +40 mEq, replacing fine ground corn. Periods were 14 days in length with an 11-day adaptation to the diet, and 3-day urine collection period. Urine pH was measured immediately after collection at 0700, 1300 and 1900 hours in all experiments. Lambs were fed once daily at 0700 for *ad libitum* intake. Lamb data were analyzed as separate 3 x 3 Latin squares with model effects for period, treatment, time and the treatment x time interaction as fixed effects and lamb as a random effect. Orthogonal contrasts were used to test significance for the highest order polynomial.

Steers

Eight steers (688 ± 53) were used in two consecutive 4 x 4 Latin squares with basal diets consisting of either dry-rolled corn (DRC) or wet distillers grains (WDGS), replacing DRC at 20% of diet DM, 7.5% alfalfa hay, 5% molasses and 5% supplement (DM). Basal diets were 8 mEq for the DRC diet and -2 mEq for the WDGS diet. Calcium chloride was used to lower DCAD to -2, -12 and -22 mEq in the DRC square and -12, -22 and -32 mEq in the WDGS square. Period length, DM offered, and urine collection procedures were the same as for the lamb experiments. In addition to urine collection, feces were collected at 0700, 1300 and 1900 hours and composited within day for pH measurement. Manure pH was analyzed using a 1:1 ratio of distilled water and as-is sample.

Urinary pH for steers was analyzed as separate 4 x 4 Latin squares with period, treatment, time and the treatment x time interaction as fixed effects and steer as a random effect. Fecal pH for steers was analyzed in a similar manner without time and the treatment x time interaction in the model. Orthogonal contrasts were used to test significance for the highest order polynomial.

Results

Lambs

Dry matter intake was not different ($P > 0.05$) among DCAD level in all experiments. In experiment 1, DMI was similar ($P = 0.81$) among treatments. Dry-matter intake decreased linearly ($P = 0.02$) with DCAD level in experiment 2. Numerically, DMI was lower for the negative DCAD treatments compared with the control (+8) or positive DCAD treatments in experiments 3, 4 and 5.

The treatment x time interaction for urinary pH was not significant ($P > 0.70$) in all experiments. Urinary pH decreased linearly ($P < 0.01$) in all experiments. The differences in urinary pH from the highest to lowest DCAD level in experiments 1 through 5 were 1.65, 2.31, 2.01, 2.65 and 2.70, respectively. From the lamb experiments it appears DCAD does not have a consistent influence on DMI but is effective in manipulating urinary pH at different levels of DCAD.

Table 1. Effect of DCAD level on DMI and urinary pH for lambs.

Experiment	DCAD[1]	DMI, lb/d	Urine pH	DMI[2]	pH[3,4]
1	0	2.93	6.67^{a}		
	8	2.88	7.09^{b}	0.81	< 0.01
	16	3.05	8.32^{c}		
2	-8	3.20	6.10^{a}		
	8	3.13	8.21^{b}	0.09	< 0.01
	24	2.97	8.41^{b}		
3	-16	2.82	6.37^{a}		
	8	3.48	8.22^{b}	0.49	< 0.01
	32	3.12	8.38^{b}		
4	-24	2.31	5.84^{a}		
	8	3.24	8.00^{b}	0.07	< 0.01
	40	3.79	8.49^{c}		
5	-45	2.15	5.88^{a}		
	8	3.13	7.98^{b}	0.13	< 0.01
	40	3.13	8.58^{c}		

[1] Dietary cation-anion difference, mEq of [(Na + K) – (Cl – S)].
[2] F-test statistic for the effect of DCAD level on DMI.
[3] F-test statistic for the effect of DCAD level on urinary pH.
[4] Linear and quadratic ($P < 0.05$) effect of DCAD level on urinary pH in all experiments.
[a,b,c] Within a column, means without a common superscript letter differ ($P < 0.05$) within each experiment.

Table 2. Effect of dietary cation-anion difference and basal diet on DMI, urinary pH and fecal pH of steers.

	DCAD[1]								
Item	8	-2	-12	-22	-32	SEM[2]	*P*-value[3]	Linear[4]	Quadratic[5]
DRC[6]									
DMI, lb/d	20.1^{a}	17.2^{ab}	18.0^{ab}	14.4^{c}		1.6	0.05	0.02	0.76
Urinary pH	7.70^{a}	6.40^{b}	5.90^{c}	5.82^{c}		0.13	< 0.01	< 0.01	< 0.01
Fecal pH	5.92	5.74	5.74	5.83		0.16	0.63	0.28	0.64
WDGS[7]									
DMI, lb/d		19.1	21.7	19.6	19.7	1.7	0.52	0.96	0.40
Urinary pH		6.14^{a}	5.88^{b}	5.71^{b}	5.90^{b}	0.10	< 0.01	< 0.01	< 0.01
Fecal pH		5.86	5.45	5.80	5.61	0.23	0.35	0.16	0.43

[1] Dietary cation-anion difference, mEq of [(Na + K) - (Cl + S)].
[2] Standard error of the mean.
[3] F-test statistic for the effect of DCAD level.
[4] Contrast for the linear effect of DCAD level within experiment.
[5] Contrast for the quadratic effect of DCAD level within experiment.
[6] Dry-rolled corn basal diet.
[7] Wet distillers grains basal diet.
[a,b,c] Within a row, means without a common superscript letter differ ($P < 0.05$).

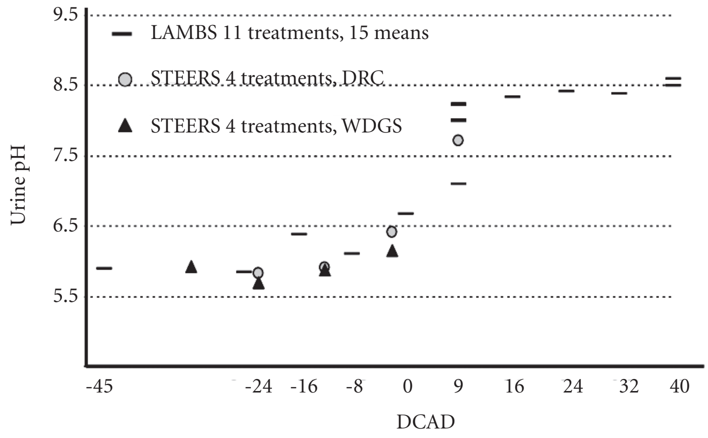

Figure 1. Effect of DCAD level on urinary pH.

Steers

Dry-matter intake for steers in the DRC experiment was greatest ($P = 0.05$) for animals consuming DCAD level +8, lowest for -32, and intermediate for -2 and -12 (Table 1). In the WDGS experiment, DMI was not influenced ($P = 0.52$) by DCAD level (Table 2). The treatment x time interaction for urinary pH was not significant in either experiment ($P > 0.60$). Urinary pH for steers in the DRC experiment decreased quadratically ($P < 0.01$) with DCAD level from 7.70 to 5.82. In the WDGS experiment urinary pH was greater ($P < 0.01$) for -2 compared with -12, -22 and -32 (7.70, 6.40, 5.90 and 5.82, respectively). Fecal pH was not different among DCAD levels in either the DRC or WDGS experiment ($P = 0.63$ and $P = 0.35$, respectively). There also was no relationship (r = 0.02, P = 0.94) of fecal pH to urine pH. Results from the steer experiments are similar to those of the lamb experiments, with an inconsistent influence of DCAD level on DMI. Urinary pH can be manipulated with DCAD level in either DRC or WDGS basal diets while fecal pH is not influenced.

The relative proportions of NH_3 compared to NH_4 are 0.1%, 1%, 10% and 50% at pH of 6, 7, 8 and 9 (Court et al., 1964 *Journal of Soil Science*). When evaluating all DCAD levels from both the lamb and steer experiments, there appears to be a consistent trend in lowering urinary pH (Figure 1). Lowering DCAD in high concentrate diets with or without WDGS decreases urinary pH and may reduce ammonia losses from steers or lambs fed negative DCAD diets.

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