ABSTRACT: Six experiments were conducted to evaluate dietary cation-anion difference (DCAD) in concentrate diets on urinary pH, feedlot performance, and N mass balance. In Exp. 1, 15 wether lambs (33.5 ± 3.0 kg) in five 3 × 3 Latin squares were fed a basal diet of 82.5% dry-rolled corn (DRC), 7.5% alfalfa hay, 5% molasses, and 5% supplement with different proportions of anionic and cationic salts. The DCAD was −45, −24, −16, −8, 0, +8, +16, +24, +32, and +40 mEq per 100 g of DM with the control basal diet (DCAD = +8) included in each square. Urinary pH increased (cubic, \(P < 0.01\)) as DCAD increased and DMI increased linearly \((P < 0.01)\) with increasing DCAD. In Exp. 2 and 3, 8 Holstein steers (312 ± 24 kg) were used in 2 consecutive 4 × 4 Latin squares. Steers were fed either the same basal diet as Exp. 1 or a basal diet with 20% wet distillers grains (WDGS) replacing DRC. In Exp. 2, DCAD was adjusted to −2, −12, and −22 mEq per 100 g of DM from the basal diet (DCAD = +8) and DCAD was adjusted in Exp. 3 to −12, −22, and −32 mEq per 100 g of DM from the basal WDGS diet (DCAD = −2). Urinary pH decreased linearly as DCAD decreased \((P < 0.01)\) in both experiments, whereas DMI decreased linearly in Exp. 2 \((P = 0.02)\) but not Exp. 3 \((P = 0.96)\).

In Exp. 4, 6 crossbred steers (373 ± 37 kg) were used in a 2-period crossover design. Steers were fed the same basal diet as Exp. 3 with DCAD of −16 (NEG) and +20 (POS) mEq per 100 g of DM. Urinary pH and DMI \((P < 0.05)\) were less for cattle fed the NEG diet compared with POS. In 2 experiments, steers \((n = 96\) each) were fed NEG or POS as calves \((260 ± 22 kg of BW)\) for 196 d from November to May (Exp. 5) or as yearlings \((339 ± 32 kg of BW)\) for 145 d from June to October (Exp. 6). Final BW, DMI, ADG, and HCW were not different \((P > 0.11)\) among treatments in either experiment. Efficiency of BW gain was increased \((P = 0.05)\) for steers fed NEG compared with POS in Exp. 5 but was not different \((P = 0.11)\) in Exp. 6. Amount of N intake, retention, excretion, and manure N (kg/steer) were not different \((P > 0.11)\) among treatments in either experiment. Manure pH (soil, feces, and urine) was decreased \((P < 0.01)\) in pens fed NEG compared with POS in both experiments. Amount of N lost (kg/steer) was not different \((P = 0.44)\) in Exp. 5, but tended \((P = 0.09)\) to be 10.6% greater for POS compared with NEG in Exp. 6. Urinary pH was decreased by reducing DCAD, but this had minimal effect on N losses in open feedlot pens in these experiments.

Key words: acid base equilibrium, finishing cattle, nitrogen, volatilization, waste management

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INTRODUCTION

Shifting the equilibrium reaction from ammonia to ammonium by acidification of cattle waste may reduce N loss. Court et al. (1964) reported the relative proportions of ammonia to ammonium are 0.1, 1, 10, and 50% at pH of 6, 7, 8, and 9, respectively. Direct addition of acid to cattle slurry has also reduced N losses during storage (Frost et al., 1990) and before spreading on fields (Stevens et al., 1989). Challenges associated with applying acid to open feedlot pens include the cost associated with application (Shi et al., 2001) and the fact that most N excretion occurs in areas of increased moisture such as around bunks and water troughs (Miller et al., 2006). The majority (60 to 80%) of N excreted by feedlot cattle is in urine (Bierman et al., 1999). Consequently, decreasing urinary pH may reduce the amount of ammonia volatilized by shifting a greater proportion of N into the ammonium form.

Urinary pH can be reduced using the dietary cation-anion difference (DCAD), defined as milliequivalents...
of \([\text{Na} + \text{K}] - (\text{Cl} + \text{S})\) per 100 g of feed DM (Ender et al., 1962). Decreasing urinary pH by modifying dietary DCAD may be less expensive than applying acid to the pen surface. Additionally, acidification of urine is site-specific and may counteract an increase in pH from urea hydrolysis. Reducing DCAD has an impact on animal performance (Ross et al., 1994a,b), blood pH (Charbonneau et al., 2006), as well as urine pH (Goff et al., 2004; Hu and Murphy, 2004). Our hypothesis is that if urine and manure pH on the pen surface can be reduced by altering DCAD in concentrate diets, N losses may be reduced.

The objectives of these experiments were to 1) determine the effect of basal diet and DCAD on DMI and urinary and fecal pH and 2) determine the effect of DCAD on steer performance, soil core and manure pH, and N mass balance.

**MATERIALS AND METHODS**

The University of Nebraska’s Institutional Animal Care and Use Committee approved all procedures and guidelines involving animals.

**Exp. 1**

Fifteen wether lambs (34 ± 3 kg of BW) were assigned randomly to one of five 3 × 3 Latin squares to determine the influence of DCAD on urinary pH and DMI in concentrate diets. Basal diets (DCAD = +8) consisted of 82.5% dry-rolled corn (DRC), 7.5% alfalfa hay, 5% molasses, and 5% supplement (DM basis; Table 1). Dietary cation-anion difference was calculated as milliequivalents (mEq) of \([\text{Na} + \text{K}] - (\text{Cl} + \text{S})\) per 100 g of feed DM. Each square consisted of 3 lambs in 3 periods with each square containing the same basal diet. Ammonium chloride, ammonium sulfate, and calcium chloride were used to decrease DCAD to 0, −8, −16, −24, and −45 mEq per 100 g of DM, replacing a portion of urea, fine-ground corn carrier, and limestone in squares 1, 2, 3, 4, and 5. Sodium bicarbonate and potassium carbonate were used to increase DCAD to +16, +24, +32, +40, and +40 mEq per 100 g of DM, replacing fine-ground corn in squares 1, 2, 3, 4, and 5, respectively. Periods were 14 d in length with 11 d of adaptation to the diet, and 3 d of spot urine collection. Lambs were housed in crates during the collection period with fecal bags to prevent feces from mixing with urine which collected in pans underneath the crates. Urine pH was measured immediately after collection at 0700, 1300, and 1900 h in all squares using a combination pH electrode (Accumet Basic pH meter, Fisher Scientific, Pittsburgh, PA). Lambs were fed once daily at 0700 h for ad libitum intake. Feed ingredient and feed refusal samples were analyzed for DM for 48 h in a 60°C forced-air oven (AOAC, 1999; method 4.2.03) and used to calculate DMI.

**Table 1. Composition of supplements (% of diet DM) fed to lambs (Exp. 1)**

<table>
<thead>
<tr>
<th>Item</th>
<th>40</th>
<th>32</th>
<th>24</th>
<th>16</th>
<th>8</th>
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<tr>
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<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
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<td>—</td>
<td>—</td>
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<td>—</td>
<td>—</td>
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<td>—</td>
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<td>—</td>
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<td>0.19</td>
<td>0.21</td>
<td>0.24</td>
<td>0.33</td>
</tr>
</tbody>
</table>

1Dietary cation-anion difference, mEq of \([\text{Na} + \text{K}] - (\text{Cl} + \text{S})\) per 100 g of DM.
2Premix contained 30,000 IU of vitamin A, 6,000 IU of vitamin D, 7.5 IU of vitamin E per gram.
3Mineral analyses were calculated from individual ingredient analysis for dry-rolled and fine-ground corn, alfalfa hay, molasses, and wet distillers grains. Ingredients in the dry supplement were calculated using tabular values. Chloride was calculated using tabular values on all ingredients.
of SAS was used to generate coefficients for unequally spaced contrasts. Linear and quadratic contrasts were also evaluated for the effect of sampling time on urinary pH.

**Exp. 2 and 3**

Based on the results of Exp. 1, two 4 × 4 Latin squares were used to determine if DCAD has a similar effect on urinary pH and DMI in steers and also determine the effect of DCAD and basal diet on fecal pH. Eight steers (312 ± 24 kg of BW) were assigned randomly to 1 of 2 experiments with basal diets consisting of 82.5% DRC, 7.5% alfalfa hay, 5% molasses, and 5% supplement (DM basis) or 20% corn wet distillers grains (WDGS) replacing a portion of DRC and molasses (Table 2). Basal diets were +8 and –2 mEq per 100 g of DM for Exp. 2 and 3, respectively. Calcium chloride was used to decrease DCAD to –2, –12, –22 mEq per 100 g of DM in Exp. 2 and –12, –22, and –32 mEq per 100 g of DM in Exp. 3 by replacing a portion of limestone and fine-ground corn carrier in the supplement. Steers were housed in 1.5 × 2.4 m slotted-floor stalls within a temperature-controlled room (25°C). Period length, DM offered, and urine pH analysis procedures were the same as described in Exp. 1. Spot urine samples were collected using 2-L buckets attached to a nylon rope. Fecal grab samples were collected at the same time as urine samples and composited (as-is basis) within day for fecal pH measurement. Daily manure pH was analyzed using a 1:1 ratio of distilled water and the as-is sample after the composite was made for each animal.

Data were analyzed as separate 4 × 4 Latin squares. Model effects for urinary pH included period, DCAD, time, day, the DCAD × time interaction, DCAD × day interaction, day × time, and the day × DCAD × time interaction. Orthogonal contrasts were used to test for linear and quadratic effects of DCAD. The Proc Corr procedure of SAS was used to determine the relationship of fecal pH to urinary pH.

**Exp. 4**

Six crossbred steers (373 ± 37 kg of BW) were used in a 2-period crossover design (n = 3 steers/treatment in each period) to determine the effect of DCAD on DMI, urinary pH, fecal pH, DM digestibility, and pH of a combined slurry of urine and feces. Basal diets consisted of high-moisture corn and DRC, fed at a constant 1:1 ratio (DM basis), 20% modified WDGS (48% DM), 7.5% alfalfa hay, and 5% supplement. Sodium bicarbonate and calcium chloride were included in the supplement to adjust DCAD to +20 mEq per 100 g of DM for the positive (POS) diet and –16 mEq per 100 g of DM for the negative (NEG) diet, respectively (Table 3). Rumensin (Elanco Animal Health, Indianapolis, IN), Tylan (Elanco Animal Health), and

| Table 2. Composition of diets (% of diet DM) fed to steers (Exp. 2 and 3) |
|------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                        | Exp. 2           | Exp. 3           |                  |                  |                  |                  |                  |
| **Item**               | **Treatment**1   | **Treatment**1   |                  |                  |                  |                  |                  |
| **Dry-rolled corn**    | 8               | –2              | –12             | –22             | –2              | –12             | –22             | –32             |
| **Wet distillers grains** | 82.5           | 82.5            | 82.5            | 82.5            | 82.5            | 82.5            | 82.5            | 82.5            |
| **Alfalfa hay**        | 7.5             | 7.5             | 7.5             | 7.5             | 7.5             | 7.5             | 7.5             | 7.5             |
| **Molasses**           | 5               | 5               | 5               | 5               | 5               | 5               | 5               | 5               |
| **Dry supplement**2    |                  |                  |                  |                  |                  |                  |                  |                  |
| **Fine-ground corn**   | 2.37            | 2.64            | 2.62            | 2.17            | 3.47            | 3.74            | 3.72            | 3.27            |
| **Limestone**          | 1.16            | 0.64            | 0.10            | –               | 1.16            | 0.64            | 0.10            | –               |
| **Trace mineral3**     | 0.05            | 0.05            | 0.05            | 0.05            | 0.05            | 0.05            | 0.05            | 0.05            |
| **Vitamin premix4**    | 0.02            | 0.02            | 0.02            | 0.02            | 0.02            | 0.02            | 0.02            | 0.02            |
| **Urea**               | 1.10            | 1.10            | 1.10            | 1.10            | 1.10            | 1.10            | 1.10            | 1.10            |
| **Salt**               | 0.30            | –               | –               | –               | 0.30            | –               | –               | –               |
| **CaCl2**              |                  | 0.55            | 1.11            | 1.66            |                  | 0.55            | 1.11            | 1.66            |

**Mineral analysis,5 %**

<table>
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<tr>
<th><strong>Item</strong></th>
<th><strong>Exp. 2</strong></th>
<th><strong>Exp. 3</strong></th>
<th><strong>Exp. 2</strong></th>
<th><strong>Exp. 3</strong></th>
<th><strong>Exp. 2</strong></th>
<th><strong>Exp. 3</strong></th>
<th><strong>Exp. 2</strong></th>
<th><strong>Exp. 3</strong></th>
<th><strong>Exp. 2</strong></th>
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<td>S</td>
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</tbody>
</table>

1 Dietary cation-anion difference, mEq of [(Na + K) – (Cl + S)] per 100 g of DM.
2 Supplement formulated to be fed at 5% of diet DM.
3 Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, and 0.05% Co.
4 Premix contained 30,000 IU of vitamin A, 6,000 IU of vitamin D, and 7.5 IU of vitamin E per gram.
5 Mineral analyses were calculated from individual ingredient analysis for dry-rolled and fine-ground corn, alfalfa hay, molasses, and wet distillers grains. Ingredients in the dry supplement were calculated using tabular values. Chloride was calculated using tabular values for all ingredients.
Table 3. Composition of diets (% of diet DM) fed to steers (Exp. 4, 5, and 6)

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<th>Item</th>
<th>Treatment</th>
<th>POS</th>
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<tr>
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<tr>
<td>Fine-ground corn</td>
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</tbody>
</table>

1 Dietary treatments: NEG = negative (−16) dietary cation-anion difference (DCAD; mEq of [(Na + K) – (Cl + S)] per 100 of DM), POS = positive (+20) DCAD.
2 Supplement formulated to be fed at 5% of diet DM.
3 Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, and 0.05% Co.
4 Premix contained 176 g/kg of monensin (Elanco Animal Health, Indianapolis, IN).
5 Premix contained 30,000 IU of vitamin A, 6,000 IU of vitamin D, and 7.5 IU of vitamin E per gram.
6 Premix contained 88 g/kg of thiamine.
7 Premix contained 88 g/kg of tyllosin (Elanco Animal Health).
8 Nutrient analyses were calculated from individual ingredient analyses for dry-rolled and fine-ground corn, alfalfa hay, molasses, and wet distillers grains. Ingredients in the dry supplement were calculated using tabular values. Chloride and ingredients in the supplement were calculated using tabular values.

The treatments were fed at 320, 90, and 130 mg/thiamine, respectively, in both experiments assuming 10 kg of DMI. Period length, DM offered, urine collection, and analysis procedures were the same as described in Exp. 1, and fecal collection and analysis procedures were the same as described in Exp. 2. Daily composites of fecal and urine samples were frozen until the end of the experiment. Upon the completion of the experiment, fecal and urine samples were thawed and combined in a 1:1 ratio of urine to feces (as-is basis) based on results in our laboratory for urine excretion and the ratio used by Shi et al. (2001). Chromic oxide (Landers-Segal Color Co., Montvale, NJ) was dosed intraruminally twice daily to provide 15 g/d on d 6 through 14 to estimate fecal output. A portion of the composited fecal sample from each steer was oven-dried and ground to pass through a 1-mm screen of a Wiley mill (Thomas Scientific). Ground fecal samples were ashed (AOAC, 1999; method 4.1.10), digested (Williams et al., 1962), and analyzed for chromium using a Varian Spectra AA-30 atomic absorption spectrophotometer (Varian, Walnut Creek, CA). Fecal output (g/d) was calculated as chromium bolused (g/d) divided by the fecal chromium concentration (g/g; Owens and Hanson, 1992).

Urine data were analyzed as a 2-period crossover design with model effects including period, DCAD, time, and the DCAD x time interaction, day x time interaction, and DCAD x day interaction, and the DCAD x time x day interaction, as well as steer as a random effect. Fecal and slurry pH data were analyzed in a similar manner as described for urine data without time, the DCAD x time and DCAD by day x time interaction in the model. Dry matter intake and digestibility were analyzed with period and DCAD as fixed effects as well as steer as a random effect.

Exp. 5 and 6

Two experiments were conducted using 96 steers each. Calves (260 ± 22 kg of BW) were fed 196 d from November to May (Exp. 5), and yearlings (339 ± 32 kg of BW) were fed 145 d from June to October (Exp. 6) to evaluate the impact of DCAD on performance and N mass balance in open feedlots using the same diets as Exp. 4 (−16 and +20 mEq per 100 g of DM). Steers were weighed initially on 2 consecutive days (d 0 and 1) after being limit-fed (1.8% of BW) a 50% alfalfa hay and 50% wet corn gluten feed diet (DM basis) for 5 d to minimize gut fill differences. The average of the 2-d BW was used as initial BW. Steers were blocked by BW, stratified within BW block, and assigned randomly to pen (8 steers/pen) based on d 0 BW. Pens were assigned randomly to 1 of 2 dietary treatments (6 pens/treatment). Basal diets were the same as Exp. 4. Monensin (Rumensin), tyllosin (Tylan), and thiamine were fed at 320, 90, and 130 mg/steer daily, respectively, in both experiments assuming 10 kg of DMI for steers in Exp. 5 and 11 kg of DMI for steers in Exp. 6. Cattle were adapted to finishing diets over a 21-d period with a series of 4 diets containing 45, 35, 25, and 15% alfalfa hay (DM basis) for 3, 4, 7, and 7 d, respectively, with the corn blend replacing alfalfa hay.

Dietary treatments were fed once daily in the morning throughout the finishing period. Steers in Exp. 5 were implanted on d 1 and 83 with Synovex Choice (Fort Dodge Animal Health, Overland Park, KS). Steers in the Exp. 6 were implanted once on d 48 with Revalor-S (Schering-Plough/Intervet Inc., Somerville, NJ). Steers were pen weighed before being shipped for slaughter on d 196 (Exp. 5) and d 145 (Exp. 6) to a commercial abattoir (Greater Omaha, Omaha, NE). Hot carcass weight and liver scores were recorded at slaughter. Fat thickness and LM area were measured after a 48-h chill, and USDA marbling score was recorded where 400 = Slight 0, 500 = Small 0. Final BW, ADG, and G:F were calculated based on HCW adjusted to a common dressing percentage of 63.
Performance and carcass data were analyzed as a randomized complete block design using the mixed procedure of SAS. Model effects included DCAD as a fixed effect and BW block as a random effect with pen serving as the experimental unit.

**Nutrient Balance**

Mass balance procedure for N was conducted similar to experiments previously outlined (Bierman et al., 1999; Erickson and Klopfenstein, 2001a; Farran et al., 2006) in 12 dirt feedlot pens with aprons. Dietary treatments were fed in the same pens for both experiments. Stocking densities were 29.6 m² for each experiment. Throughout the feeding period, feed refusals were collected and sampled to determine DM and N intake. When rainfall occurred, runoff collected in 7 earthen retention ponds constructed of soil. Within 8 h after a rainfall event, effluent was drained from each pond and quantified using an ISCO model 4230 air bubble flow meter (ISCO, Lincoln, NE). Samples of effluent (6/pond) were collected and frozen (−4°C) for later analysis. Pens assigned to the same dietary treatment drained into the same runoff retention pond, and no more than 2 pens drained into one pond. Because runoff is not a large contributor to nutrient losses (Gilbertson et al., 1971; Adams et al., 2004; Farran et al., 2006), this approach was used in estimating N mass balance for individual pens. To determine soil pH, soil was sampled before cattle were placed into the pens and again after pens were cleaned (i.e., after the cattle were marketed). Sixteen soil cores (15 cm long, 2.5 cm wide) were obtained from each pen. The day after cattle were removed from the pens for slaughter, manure was scraped with a skid steer loader and piled on a cement apron. While manure was loaded into trucks for removal from the pens, 30 replicate samples were collected from each pen for nutrient analysis. Manure was weighed before it was hauled to the University of Nebraska compost yard.

After pen cleaning and core sampling, a portion of the manure samples and the soil core samples were analyzed for pH using a 1:1 ratio of distilled water and the as-is sample. Similarly, a portion of the manure samples were oven-dried for 48 h at 60°C (AOAC, 1999; method 4.2.03) to determine DM content and calculated amount removed from pens. Once collected, all samples were frozen at −4°C until analysis. To avoid N losses during the drying process, manure samples were freeze-dried using a Virtis Freezemobile model 25 SL (Virtis, Gardiner, NY). Ingredient samples and feed refusals were also oven-dried for 48 h at 60°C. Feed refusals and manure samples were composted by pen. Feed ingredient samples were collected weekly and composited by month. All samples were ground through a Wiley mill (1-mm screen) and ashed at 600°C for 6 h (AOAC, 1999; method 4.1.10). Runoff was composted by pond using a weighted average based on runoff quantity, and analyzed for DM and N content by a commercial laboratory (Ward Laboratories, Kearney, NE). Total N (AOAC, 1999; method 4.2.04) for feed ingredient, feed refusals, and manure was determined using a combustion method N analyzer (Leco FP 528, Leco Corp., St. Joseph, MI).

Amount of manure N and OM was calculated by multiplying manure nutrient concentration (kg of nutrient/kg of DM) by kilograms of manure DM removed from the pen surface. Runoff N was calculated using nutrient concentration in the runoff multiplied by the volume of water collected. Nitrogen intake was calculated using analyzed N content of individual dietary ingredients multiplied by DMI and ingredient inclusion amount and corrected for N content of feed refusals. Retained protein was calculated using the NRC (1996) NE and protein equations for individual animals and averaged by pen.

Nitrogen excretion was calculated by subtracting N retention from intake (ASAE, 2005). Total N lost (kg/steer) was calculated by subtracting manure N from excreted N. Percentage of N loss was calculated as N lost (N not accounted for in the manure, runoff, or retained by the animal) divided by N excretion.

Mass balance data were analyzed as a completely randomized design using the Mixed procedure of SAS. Model effects for mass balance estimates included the main effect of dietary treatment. Stepwise multiple regression analysis were performed to determine the effect of manure pH, initial soil core pH, and final soil core pH on the amount of N lost, percentage of N loss, and amount of manure N removed during pen cleaning.

**RESULTS AND DISCUSSION**

**Exp. 1**

Dry matter intake for lambs decreased linearly \((P = 0.02)\) as DCAD decreased (Table 4). The main effect of square did not have an effect \((P = 0.64)\) on DMI. The treatment \(\times\) time interaction was not significant \((P = 0.20)\) for urinary pH. There was a cubic response \((P < 0.01)\) to DCAD for urinary pH (linear \(P < 0.01\), quadratic \(P = 0.86\); Figure 1). In a meta-analysis conducted by Hu and Murphy (2004), the authors observed a quadratic relationship of urinary pH and DCAD from −19 to 64 mEq per 100 g of DM. The difference in the relationship between urinary pH and DCAD in the meta-analysis compared with the current experiment may be the use of decreased DCAD diets in our experiment. Urinary pH was less \((P < 0.01)\) for square 1 compared with squares 2 through 5 (6.44, 7.55, 7.57, 7.31, and 7.35, respectively). When square was not included in the model, unadjusted urinary pH for square 1 was 6.67, 7.09, and 8.32 for DCAD 0, +8, and +16 mEq per 100 g of DM, respectively. Urinary pH for the basal diet (DCAD = +8 mEq per 100 g of DM) in squares 2 through 5 was 8.21, 8.22, 8.00, and 7.98, respectively. Because the model corrected urinary pH for square 1, the values for the 0 and +16 mEq per
100 g of DM treatments increased 0.80 pH units. This adjustment resulted in a mean urinary pH for the +16 mEq per 100 g of DM treatment to be greater than the maximum measured in the experiment (pH = 9.12). As a generalization, urinary pH uncorrected for square was similar for treatments −45 through −8 mEq per 100 g of DM, an increase was observed from −8 to +16 mEq per 100 g of DM, and further increases were not observed from +16 to +40 mEq per 100 g of DM. Urinary pH linearly decreased (P < 0.01) throughout the sampling day from 7.33 to 7.21 and 7.19 at 0700 h, 1300, and 1900 h, respectively.

**Exp. 2 and 3**

Dry matter intake in Exp. 2 was greatest (P = 0.05) for steers consuming the basal diet (DCAD = +8 mEq per 100 g of DM), least for −32 mEq per 100 g of DM, and intermediate for −2 and −12 mEq per 100 g of DM (Table 4). In Exp. 3, DMI was not influenced (P = 0.52) by DCAD. Two theories for the reduced DMI observed in Exp. 1 and 2 when anionic salts were fed may include decreased palatability and possibly the feed intake control due to systemic acidosis itself when the animal is trying to decrease the acid load (Oetzel and Barmore, 1993; Vagnoni and Oetzel, 1998). Inclusion of WDGS in the diet may mask the unpalatable characteristics when anionic salts are fed. The DCAD × time interaction for urinary pH was not significant in either experiment (P > 0.60). Urinary pH for steers in Exp. 2 decreased quadratically (P < 0.01) with DCAD from 7.70 to 5.82. In Exp. 3, urinary pH was greater (P < 0.01) for −2 compared with −12, −22, and −32 mEq per 100 g of DM (7.70, 6.40, 5.90, and 5.82, respectively). Fecal pH was not different among DCAD in Exp. 2 or 3 (P = 0.63 and P = 0.35, respectively). Similarly, fecal pH and urinary pH were not related in Exp. 2 (r = 0.06, P = 0.84) or Exp. 3 (r = 0.34, P = 0.20).

**Exp. 4**

Dry matter intake was greater (P = 0.02) for steers consuming the POS treatment compared with NEG (Table 6). Dry matter digestibility was not different (P

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**Table 4. Effect of dietary cation-anion difference on DMI and urinary pH of lambs (Exp. 1)**

<table>
<thead>
<tr>
<th>Item</th>
<th>40</th>
<th>32</th>
<th>24</th>
<th>16</th>
<th>8</th>
<th>0</th>
<th>−8</th>
<th>−16</th>
<th>−24</th>
<th>−45</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urinary pH&lt;sup&gt;2,3,4&lt;/sup&gt;</td>
<td>8.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.10&lt;sup&gt;c&lt;/sup&gt;</td>
<td>9.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.90&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.47&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.79&lt;sup&gt;e&lt;/sup&gt;</td>
<td>6.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.77&lt;sup&gt;e&lt;/sup&gt;</td>
<td>5.80&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.15</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>DMI, kg/d&lt;sup&gt;5&lt;/sup&gt;</td>
<td>1.56&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.28&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>1.37&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>1.52&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.44&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.46&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.47&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.14&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.95&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.15</td>
<td>0.02</td>
</tr>
</tbody>
</table>

<sup>a</sup>Within a row, means without a common superscript letter differ (P < 0.05).
<sup>1</sup>Dietary cation-anion difference (DCAD), mEq of [(Na + K) – (Cl – S)] per 100 g of DM.
<sup>2</sup>Cubic effect of DCAD (P < 0.01).
<sup>3</sup>DCAD × day interaction (P = 0.50), day × time interaction (P = 0.17), DCAD × time interaction (P = 0.06), day × DCAD × time interaction (P = 0.82).
Table 5. Effect of dietary cation-anion difference (DCAD) on steer DMI and fecal and urine pH in dry-rolled corn-based (DRC) or wet distillers grains with solubles-based (WDGS) diets (Exp. 2 and 3)

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment1</th>
<th>SEM</th>
<th>F-test</th>
<th>Lin</th>
<th>Quad</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>−2</td>
<td>−12</td>
<td>−22</td>
<td>−32</td>
</tr>
<tr>
<td>DRC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinary pH</td>
<td>7.70a</td>
<td>6.40b</td>
<td>5.90c</td>
<td>5.82c</td>
<td>—</td>
</tr>
<tr>
<td>Fecal pH</td>
<td>5.92</td>
<td>5.74</td>
<td>5.74</td>
<td>5.83</td>
<td>—</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>9.1ab</td>
<td>7.8ab</td>
<td>8.1ab</td>
<td>6.5b</td>
<td>—</td>
</tr>
<tr>
<td>WDGS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinary pH</td>
<td>—</td>
<td>6.14a</td>
<td>5.88b</td>
<td>5.71b</td>
<td>5.90b</td>
</tr>
<tr>
<td>Fecal pH</td>
<td>—</td>
<td>5.86</td>
<td>5.45</td>
<td>5.80</td>
<td>5.61</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>—</td>
<td>8.7</td>
<td>9.9</td>
<td>8.9</td>
<td>8.9</td>
</tr>
</tbody>
</table>

**Within a row, means without a common superscript letter differ (**P** < 0.05).**

1DCAD, mEq of [(Na + K) − (Cl + S)] per 100 g of DM.

2F-test = overall F-test representing variation due to treatment within experiment, Lin = linear effect of DCAD within experiment, and Quad = quadratic effect DCAD within experiment.

3DRC basal diet in Exp. 2.

4DCAD × day interaction (**P** = 0.22), day × time interaction (**P** = 0.99), DCAD × time interaction (**P** = 0.64), day × DCAD × time interaction (**P** = 0.76).

5WDGS basal diet in Exp. 3.

6DCAD × day interaction (**P** = 0.95), day × time interaction (**P** = 0.25), DCAD × time interaction (**P** = 0.69), day × DCAD × time interaction (**P** = 0.79).

Table 6. Effect of dietary cation-anion difference (DCAD) on steer DMI, DM digestibility, and urinary, fecal, and slurry pH (Exp. 4)

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment1</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, kg/d</td>
<td>NEG 11.3</td>
<td>12.4</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>POS 8.7</td>
<td>9.9</td>
<td>0.17</td>
</tr>
<tr>
<td>Urine pH</td>
<td>NEG 5.77</td>
<td>7.44</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>POS 7.01</td>
<td>6.94</td>
<td>0.10</td>
</tr>
<tr>
<td>Feces pH</td>
<td>NEG 78.7</td>
<td>78.3</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>POS 78.1</td>
<td>8.01</td>
<td>0.17</td>
</tr>
<tr>
<td>Slurry pH (1:1)</td>
<td>NEG 7.58</td>
<td>8.24</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>POS 7.81</td>
<td>8.01</td>
<td>0.17</td>
</tr>
</tbody>
</table>

**NEG = negative DCAD (−16 mEq per 100 g of DM); POS = positive DCAD (+20 mEq per 100 g of DM).**

2DCAD × day interaction (**P** = 0.59), day × time interaction (**P** = 0.85), DCAD × time interaction (**P** = 0.55), day × DCAD × time interaction (**P** = 0.99).

3Urine and feces mixed at a 1:1 ratio (as is).

4Urine and feces mixed at a 2:1 ratio (as is).
be greater for steers consuming the NEG treatment. In Exp. 6, steers fed the POS diet had improved \( P = 0.04 \) marbling scores compared with the NEG treatment. Hot carcass weight, LM area, 12th-rib fat depth, and incidence of liver abscesses were not different \( P > 0.05 \) among treatments in either experiment.

The improvement in G:F for steers fed the NEG treatment compared with the POS treatment was 7.2 and 3.8% in Exp. 5 and 6, respectively. The improvement in G:F with reduced DCAD contradicts the results of Ross et al. (1994a) and Hu and Murphy (2004). Ross et al. (1994a) observed DMI and ADG to respond in a quadratic manner for steers fed 0, 15, 30, and 45 mEq per 100 g of DM diets with the optimum amount at 15 mEq per 100 g of DM. In a meta-analysis to determine the relationship of DCAD to milk production in dairy cows, Hu and Murphy (2004) observed a quadratic response to DCAD for milk yield, 4% fat corrected milk, and milk fat yield with peak yields at 34, 49, and 40 mEq per 100 g of DM, respectively. In

### Table 7. Animal performance and carcass characteristics of finishing steers (Exp. 5)\(^1\)

<table>
<thead>
<tr>
<th>Item</th>
<th>NEG</th>
<th>POS</th>
<th>SEM</th>
<th>( F )-test 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pen replicates</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial BW, kg</td>
<td>260</td>
<td>261</td>
<td>8</td>
<td>0.95</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>566</td>
<td>559</td>
<td>11</td>
<td>0.54</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>8.8</td>
<td>9.1</td>
<td>0.22</td>
<td>0.12</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>1.56</td>
<td>1.53</td>
<td>0.05</td>
<td>0.46</td>
</tr>
<tr>
<td>G:F</td>
<td>0.179</td>
<td>0.167</td>
<td>0.005</td>
<td>0.05</td>
</tr>
<tr>
<td>Carcass characteristic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCW, kg</td>
<td>357</td>
<td>352</td>
<td>7</td>
<td>0.55</td>
</tr>
<tr>
<td>Marbling score(^5)</td>
<td>586</td>
<td>585</td>
<td>18</td>
<td>0.99</td>
</tr>
<tr>
<td>LM area, cm(^2)</td>
<td>83</td>
<td>80</td>
<td>2</td>
<td>0.08</td>
</tr>
<tr>
<td>12th-rib fat depth, cm</td>
<td>1.49</td>
<td>1.58</td>
<td>0.10</td>
<td>0.37</td>
</tr>
<tr>
<td>Liver abscess, %</td>
<td>7.2</td>
<td>6.3</td>
<td>6.1</td>
<td>0.89</td>
</tr>
</tbody>
</table>

\(^1\)Cattle were fed 196 d from November to May.
\(^2\)NEG = negative dietary cation-anion differences (−16 mEq per 100 g of DM); POS = positive dietary cation-anion difference (+20 mEq per 100 g of DM).
\(^3\)Data were analyzed using a protected \( F \)-test where numbers represent \( P \)-value for variation due to treatment.
\(^4\)Calculated from HCW, adjusted to a common dressing percentage of 63.
\(^5\)400 = Slight 0, 500 = Small 0.

### Table 8. Animal performance and carcass characteristics of finishing steers in Exp. 6\(^1\)

<table>
<thead>
<tr>
<th>Item</th>
<th>NEG</th>
<th>POS</th>
<th>SEM</th>
<th>( F )-test 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pen replicates</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial BW, kg</td>
<td>344</td>
<td>345</td>
<td>2</td>
<td>0.62</td>
</tr>
<tr>
<td>Final BW, kg</td>
<td>610</td>
<td>610</td>
<td>7</td>
<td>0.99</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>11.1</td>
<td>11.4</td>
<td>0.2</td>
<td>0.17</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>1.84</td>
<td>1.84</td>
<td>0.04</td>
<td>0.82</td>
</tr>
<tr>
<td>G:F</td>
<td>0.166</td>
<td>0.160</td>
<td>0.004</td>
<td>0.11</td>
</tr>
<tr>
<td>Carcass characteristic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCW, kg</td>
<td>384</td>
<td>384</td>
<td>4</td>
<td>0.97</td>
</tr>
<tr>
<td>Marbling score(^5)</td>
<td>523</td>
<td>543</td>
<td>8</td>
<td>0.04</td>
</tr>
<tr>
<td>LM area, cm(^2)</td>
<td>80</td>
<td>80</td>
<td>2</td>
<td>0.99</td>
</tr>
<tr>
<td>12th-rib fat depth, cm</td>
<td>1.50</td>
<td>1.44</td>
<td>0.08</td>
<td>0.52</td>
</tr>
<tr>
<td>Liver abscess, %</td>
<td>8.5</td>
<td>14.8</td>
<td>5.7</td>
<td>0.29</td>
</tr>
</tbody>
</table>

\(^1\)Cattle were fed 145 d from June to October.
\(^2\)NEG = negative dietary cation-anion differences (−16 mEq per 100 g of DM); POS = positive dietary cation-anion difference (+20 mEq per 100 g of DM).
\(^3\)Data were analyzed using a protected \( F \)-test where numbers represent \( P \)-value for variation due to treatment.
\(^4\)Calculated from HCW, adjusted to a common dressing percentage of 63.
\(^5\)400 = Slight 0, 500 = Small 0.
the current experiments, steers fed NEG diets had a reduced DMI, but similar ADG, resulting in an improved G:F for steers fed the NEG.

Nitrogen intake, calculated retention, and excretion were not different \((P > 0.10)\) among treatments in either experiment (Tables 9 and 10). Calculated N retention as a percentage of N intake was not different among treatments in either experiment and averaged 16.1 and 13.8% in Exp. 5 and 6, respectively. The numeric difference for percentage of N retained between experiments is due in part to initial animal BW (260 and 339 kg in Exp. 5 and 6, respectively) and composition of BW gain. When mature BW is similar, steers with a reduced average BW deposit more lean tissue as a percentage of BW compared with adipose tissue (Klopfenstein and Erickson, 2002). The percent N in runoff of excreted N was 1.7 and 2.2% in Exp. 5 and 6, respectively. The 29% increase in amount of N in runoff for Exp. 6 compared with Exp. 5 may be due to the total amount of effluent collected from the retention ponds (62,362 and 92,676 L/steer, respectively), which is similar to the total amount of effluent of Adams et al. (2004) and M. K. Luebbe, G. E. Erickson, T. J. Klopfenstein, and M. A. Greenquist (unpublished data). However, these losses are not a large portion of the mass balance (Bierman et al., 1999; Erickson and Klopfenstein, 2001a,b; Farran et al., 2006).

The amount of N lost (kg/steer) to volatilization and runoff was not different \((P = 0.44)\) among treatments in Exp. 5. The amount of N lost during Exp. 6 tended \((P = 0.08)\) to be 10.6% greater for pens fed the POS treatment compared with NEG. The difference in amount of N lost during Exp. 6 may be due in part to the numerically greater amount of N intake and excretion for cattle fed the POS diet. These results are similar to those observed by Erickson and Klopfenstein (2001a) where the amount of N lost was less for pens that consumed and excreted less N. Percentage of N lost \((N \text{ lost }/N \text{ excreted})\) was not different \((P > 0.25)\) among treatments in either experiment. Percent N lost averaged 45.7 and 65.6% in Exp. 5 and 6, respectively. Because the majority (60 to 80%) of N excreted by feedlot cattle is in the urine as urea (Bierman et al., 1999) and urea is rapidly converted into ammonium and ammonia, methods such as decreasing manure pH should decrease N lost as volatilized ammonia. Todd et al. (2005) estimated ammonia N losses to be 91% of gaseous N loss.

Seasonal variation may play an important role in the amount of N loss. Adriano et al. (1974) observed N losses were increased when temperature increased from 10 to 25°C (26 to 39% N loss, respectively). Similarly, Dewes (1996) observed N losses from manure increased when temperature increased from 20 to 40°C. An increase in the percent N loss for cattle fed during the summer compared with winter has been reported in similar experiments (Erickson and Klopfenstein, 2001b; Klopfenstein and Erickson, 2002; Adams et al., 2004). In the summary of N mass balance for open feedlot pens in summer compared with winter, Kissinger et al. (2006) observed greater losses of N in the summer compared with the winter (69.0 and 47.2%, respectively), similar to what was observed in the current experiments.

Amount of manure DM, OM, and as-is sample removed (soil, feces, urine, and water), as well as percent DM and percent N in manure were not different \((P > 0.10)\) among treatments in either experiment (Tables 11 and 12). Initial soil core pH for pens in Exp. 5 was greater \((P = 0.04)\) for cattle receiving NEG compared

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### Table 9. Effect of dietary cation-anion difference (DCAD) on N mass balance in Exp. 5[^1]

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>SEM</th>
<th>F-test[^3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pen replicates</td>
<td>NEG 6</td>
<td>POS 6</td>
<td>—</td>
</tr>
<tr>
<td>N intake</td>
<td>39.4</td>
<td>40.7</td>
<td>1.0</td>
</tr>
<tr>
<td>N retention[^4]</td>
<td>6.4</td>
<td>6.5</td>
<td>0.2</td>
</tr>
<tr>
<td>N excretion[^5]</td>
<td>33.0</td>
<td>34.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Manure N</td>
<td>18.8</td>
<td>17.7</td>
<td>2.9</td>
</tr>
<tr>
<td>N lost[^6]</td>
<td>14.2</td>
<td>16.5</td>
<td>2.8</td>
</tr>
<tr>
<td>N loss, %[^7]</td>
<td>43.0</td>
<td>48.4</td>
<td>8.5</td>
</tr>
<tr>
<td>Pond replicates</td>
<td>3</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>Runoff N[^8]</td>
<td>0.49 ± 0.09</td>
<td>0.70 ± 0.28</td>
<td>—</td>
</tr>
</tbody>
</table>

[^1]: Cattle were fed 196 d from November to May. Except where noted, values are expressed as kilograms per steer over the 196-d feeding period.
[^2]: NEG = negative DCAD (−16 mEq per 100 g of DM); POS = positive DCAD (+20 mEq per 100 g of DM).
[^3]: Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[^5]: Calculated as N intake minus N retention.
[^6]: Calculated as N excretion minus manure N. The majority of N is lost to volatilization.
[^7]: Calculated as N lost divided by N excretion.
[^8]: Mean ± SD.
with those receiving POS (Table 11). However, final soil core pH in Exp. 5 was greater \((P < 0.01)\) in pens with cattle fed POS compared with NEG. Manure pH (soil, feces, and urine) in Exp. 5 was greater \((P < 0.01)\) for POS compared with NEG. Initial soil core pH in Exp. 6 was greater \((P = 0.04)\) for POS compared with NEG, but final soil core pH was not different \((P = 0.29)\) among treatments. Manure pH in Exp. 6 was greater \((P < 0.01)\) for POS compared with NEG. Differences observed for manure pH and final soil core pH did not correspond with N mass balance. In Exp. 5, manure pH, initial soil core pH, and final soil core pH did not explain a significant \((P > 0.15)\) amount of variability for manure N, N lost, or percent N loss. In Exp. 6, initial soil core pH explained 40% \((P = 0.03)\) of the variation for the amount of N lost and 31% \((P = 0.06)\) of the variation for percent N loss. Our hypothesis was that N excreted in the urine would mix primarily with manure in areas of the pen (along the bunk pad and water tank; Miller et al., 2006), which may result in manure pH being a better indicator of N loss. The magnitude of the decrease in soil core and manure pH was likely not sufficient to decrease N losses in open feedlot pens because calcium carbonate is excreted in the feces (Ferreira et al., 1980; Eghball, 2002). In addition, the buffering capacity of the soil (Russell et al., 2005) in open feedlot pens appears to be great enough to offset the lower urinary pH of cattle fed negative DCAD diets.

There was a consistent effect of DCAD on manure (soil, urine, and feces) pH removed from the pen surface. After removing manure from the pen surface, the impact of cattle excreting urine with a reduced pH did

### Table 10. Effect of dietary cation-anion difference (DCAD) on N mass balance in Exp. 6

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>SEM</th>
<th>(F)-test (^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pen replicates</td>
<td>NEG</td>
<td>6</td>
<td>—</td>
</tr>
<tr>
<td>N intake</td>
<td>POS</td>
<td>6</td>
<td>—</td>
</tr>
<tr>
<td>N retention (^4)</td>
<td>NEG</td>
<td>5.2</td>
<td>0.8</td>
</tr>
<tr>
<td>N excretion (^5)</td>
<td>POS</td>
<td>5.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Manure N</td>
<td>NEG</td>
<td>31.9</td>
<td>0.76</td>
</tr>
<tr>
<td>N lost (^6)</td>
<td>POS</td>
<td>33.2</td>
<td>0.11</td>
</tr>
<tr>
<td>N loss, (^7) %</td>
<td>NEG</td>
<td>20.2</td>
<td>1.5</td>
</tr>
<tr>
<td>POS</td>
<td>22.2</td>
<td>1.2</td>
<td>0.08</td>
</tr>
<tr>
<td>Pond replicates</td>
<td>NEG</td>
<td>64.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Pond replicates</td>
<td>POS</td>
<td>67.2</td>
<td>4.0</td>
</tr>
<tr>
<td>Runoff N (^8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NEG</td>
<td>0.69±0.45</td>
<td></td>
</tr>
<tr>
<td></td>
<td>POS</td>
<td>0.78±0.16</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)Cattle were fed 145 d from June to October. Except where noted, values are expressed as kilograms per steer over the 145-d feeding period.

\(^2\)NEG = negative DCAD \((-16\ \text{mEq per 100 g of DM});\) POS = positive DCAD \((+20\ \text{mEq per 100 g of DM}).\)

\(^3\)Data were analyzed using a protected \(F\)-test where numbers represent \(P\)-value for variation due to treatment.

\(^4\)Calculated using NRC (1996) net protein and NE equations.

\(^5\)Calculated as N intake minus N retention.

\(^6\)Calculated as N excretion minus manure N. The majority of N is lost to volatilization.

\(^7\)Calculated as N lost divided by N excretion.

\(^8\)Mean ± SD.

### Table 11. Effect of dietary treatment on manure removed from the pen surface in Exp. 5

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>SEM</th>
<th>(F)-test (^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-is sample removal, kg/steer</td>
<td>NEG</td>
<td>2,922</td>
<td>522</td>
</tr>
<tr>
<td>% DM</td>
<td>POS</td>
<td>2,810</td>
<td>0.83</td>
</tr>
<tr>
<td>DM removed, kg/steer</td>
<td>NEG</td>
<td>66.1</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>POS</td>
<td>66.3</td>
<td>0.91</td>
</tr>
<tr>
<td>OM removed, kg/steer</td>
<td>NEG</td>
<td>1,933</td>
<td>366</td>
</tr>
<tr>
<td></td>
<td>POS</td>
<td>1,869</td>
<td>0.86</td>
</tr>
<tr>
<td>% N</td>
<td>NEG</td>
<td>224</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>POS</td>
<td>234</td>
<td>0.77</td>
</tr>
<tr>
<td>Initial soil core pH</td>
<td>NEG</td>
<td>0.98</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>POS</td>
<td>0.95</td>
<td>0.55</td>
</tr>
<tr>
<td>Final soil core pH</td>
<td>NEG</td>
<td>8.52</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>POS</td>
<td>8.39</td>
<td>0.04</td>
</tr>
<tr>
<td>Manure pH</td>
<td>NEG</td>
<td>8.52</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>POS</td>
<td>8.70</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

\(^1\)Cattle were fed 196 d from November to May.

\(^2\)NEG = negative dietary cation-anion differences \((-16\ \text{mEq per 100 g of DM});\) POS = positive dietary cation-anion difference \((+20\ \text{mEq per 100 g of DM}).\)

\(^3\)Data were analyzed using a protected \(F\)-test where numbers represent \(P\)-value for variation due to treatment.
not influence soil core pH. In confined production systems with surfaced pens or slatted floors, the impact of feeding diets that result in slurry with a reduced pH may have a larger effect on reducing N losses because soil will not buffer against urinary acids. In Exp. 1, 2, and 3, the first level of anionic salts included in the diets appeared to have the largest effect on urinary pH compared with the basal diet. Urinary pH among all experiments aligned well across DCAD, basal diets, and species (Figure 1).

Feeding negative DCAD diets reduced urinary pH, but did not affect fecal pH. When urine and feces were combined at a 2:1 ratio, the DCAD had an impact on slurry pH. The influence of feeding concentrate diets with reduced DCAD is not consistent for DMI and may depend on the basal diet in addition to DCAD. Feedlot performance does not appear to be negatively affected with negative DCAD finishing diets that contain WDGS. The amount of N in runoff is small and may have a larger effect on reducing N losses because soil will not buffer against urinary acids. In Exp. 1, 2, and 3, the first level of anionic salts included in the diets appeared to have the largest effect on urine pH compared with the basal diet. Urinary pH among all experiments aligned well across DCAD, basal diets, and species (Figure 1).

**Table 12.** Effect of dietary treatment on manure removed from the pen surface in Exp. 6

<table>
<thead>
<tr>
<th>Item</th>
<th>NEG</th>
<th>POS</th>
<th>SEM</th>
<th>P-test&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-is sample removal, kg/steer</td>
<td>1.645</td>
<td>1.762</td>
<td>256</td>
<td>0.66</td>
</tr>
<tr>
<td>% DM</td>
<td>66.0</td>
<td>66.8</td>
<td>1.5</td>
<td>0.60</td>
</tr>
<tr>
<td>DM removed, kg/steer</td>
<td>1.088</td>
<td>1.179</td>
<td>174</td>
<td>0.61</td>
</tr>
<tr>
<td>OM removed, kg/steer</td>
<td>174</td>
<td>172</td>
<td>79</td>
<td>0.92</td>
</tr>
<tr>
<td>% N</td>
<td>1.11</td>
<td>0.95</td>
<td>0.09</td>
<td>0.12</td>
</tr>
<tr>
<td>Initial soil core pH</td>
<td>8.52</td>
<td>8.70</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Final soil core pH</td>
<td>8.01</td>
<td>8.07</td>
<td>0.06</td>
<td>0.29</td>
</tr>
<tr>
<td>Manure pH</td>
<td>7.70</td>
<td>8.12</td>
<td>0.07</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

<sup>1</sup>Cattle were fed 145 d from June to October.

<sup>2</sup>NEG = negative dietary cation-anion differences (−16 mEq per 100 g of DM); POS = positive dietary cation-anion difference (+20 mEq per 100 g of DM).

<sup>3</sup>Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.

**LITERATURE CITED**


