Effect of Dietary Cation-Anion Difference on Feedlot Performance, Nitrogen Mass Balance and Manure pH in Open Feedlot Pens

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Summary

Two experiments were conducted to evaluate the effect of dietary cation-anion difference (DCAD) at two levels (-16 and +20 mEq) on feedlot performance and nutrient mass balance in open feedlots. Decreasing DCAD did not negatively impact cattle performance or carcass characteristics. Feeding negative DCAD diets resulted in lower manure pH in both the winter and summer experiments. Final soil core pH was reduced only in the winter experiment. Percentage of N lost was not influenced by DCAD in either experiment. The decrease in manure pH is likely not enough to reduce the amount of N lost in open feedlot pens.

Introduction

Direct addition of acid to cattle slurry has reduced N losses during storage (Frost et al., 1990, *Journal of Agricultural Science*), and prior to spreading slurry (Stevens et al., 1989, *Journal of Agricultural Science*). Reducing urine and fecal pH on the pen surface may reduce the amount of N lost from open feedlot pens. Urinary pH can be lowered using the dietary cation-anion difference (DCAD, defined as milliequivalents (mEq) of [(Na + K) – (Cl + S)] per 100 g of feed DM). The majority (60-80%) of N excreted by feedlot cattle is in the urine as urea, which is converted into ammonium by the urease enzyme. Lowering urinary pH may reduce the amount of ammonia volatilized by shifting a greater proportion of N into the ammonium form. The objectives of these studies were to evaluate effects of DCAD level on steer performance, soil core and manure pH, and N mass balance.

Procedure

Cattle Performance

Two experiments were conducted using 96 steers each; calves (573 ± 48 lb BW) were fed 196 days from November to May (WINTER) and yearlings (760 ± 56 lb BW) fed 145 days from June to October (SUMMER) to evaluate DCAD level on N balance, manure pH and soil core pH in open feedlots. Steers were blocked by BW, stratified within block and assigned randomly to pen (eight steers/pen). Dietary treatments consisted of negative (-16 mEq, NEG) and positive (+20 mEq, POS) DCAD levels. Basal diets for both experiments consisted of high-moisture and dry-rolled corn fed at a 1:1 ratio, 20% WDGS, 7.5% alfalfa hay and 5% supplement (DM basis). Sodium bicarbonate (1.2% diet DM) replaced a portion of fine ground corn in the positive diet and calcium chloride (0.75% diet DM) replaced a portion of fine ground corn and limestone in the negative diet. Calcium, phosphorus, potassium and sulfur were held constant at 0.65%, 0.40%, 0.72% and 0.33%, respectively, in all diets. Cattle were adapted to finishing diets over a 21-day period, with the corn blend replacing alfalfa hay. Rumensin, Tylan and thiamine premix were formulated for 320, 90 and 130 mg/head/day, respectively, in both experiments assuming a 22 lb dry matter intake (DMI) for WINTER and 24.5 lb DMI for SUMMER.

Steers in the WINTER experiment were implanted on day 1 and day 83 with Synovex Choice (Fort Dodge Animal Health, Overland Park, Kan.). Steers in the SUMMER experiment were implanted once on day 48 with Revalor-S (Intervet Inc. Somerville, N.J.). Steers were slaughtered on day 196 (WINTER) and day 145 (SUMMER) at a commercial abattoir (Greater Omaha, Omaha, Neb.). Hot carcass weights (HCW) and liver scores were recorded on day of slaughter. Fat thickness and LM area were measured after a 48-hour chill, and USDA called marbling score was recorded. Final BW, average daily gain (ADG) and feed-to-gain ratio (F:G) were calculated based on hot carcass weights adjusted to a common dressing percentage of 63%.

Nutrient Balance

Nutrient mass balance experiments were conducted using 12 open feedlot pens with retention ponds to collect runoff. When rainfall occurred, the runoff collected in the retention ponds was drained and quantified using an air bubble flow meter (ISCO, Lincoln, Neb.). Before placing cattle in pens, 16 soil core samples (6-in depth) were taken from each pen in both experiments. After cattle were removed from pens, scraped manure was piled on a cement apron and sampled (n = 30) for nutrient analysis while being loaded. Manure was weighed before it was hauled to the University of Nebraska compost yard. Manure was freeze-dried for nutrient analysis and oven-dried for DM removal calculation. After manure was removed in a manner identical to removal before the experiments, soil core samples were taken from each pen. Soil core samples and manure from pen cleaning were analyzed for pH using a 1:1 ratio of distilled water and as-is sample. Dietary treatments were fed in the same pens for both experiments.

(Continued on next page)

Table 1. **Growth performance and carcass characteristics for steers fed during WINTER.**

Dietary Treatment[1]:	NEG	POS	SEM	*P*-value
Performance				
Initial BW, lb	574	574	18	0.96
Final BW, lb[2]	1248	1234	24	0.56
DMI, lb/d	19.3	20.1	0.5	0.12
ADG, lb	3.44	3.37	0.11	0.48
Feed: gain[3]	5.66	6.14	0.17	0.05
Carcass characteristics				
Hot carcass weight, lb	787	777	15	0.55
Marbling score[4]	586	586	18	0.99
LM, area in^2.	12.9	12.4	0.3	0.08
12th rib fat, in.	0.59	0.62	0.04	0.39
Yield grade[5]	3.4	3.6	0.1	0.10
Liver abscess, %	7.2	6.3	6.1	0.89

[1]Dietary treatments: NEG = negative dietary cation-anion difference (-16 mEq); POS = positive dietary cation-anion difference (+20 mEq).
[2]Calculated from hot carcass weight, adjusted to a common dressing percentage of 63.
[3]Analyzed as gain:feed, reciprocal of feed conversion.
[4]Marbling score: 400 = $Slight^0$; 450 = $Slight^{50}$; 500 = $Small^0$, etc..
[5]Where yield grade = 2.5 + 2.5(fat thickness, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038(hot carcass weight, lb).

Table 2. **Growth performance and carcass characteristics for steers fed during SUMMER.**

Dietary Treatment[1]:	NEG	POS	SEM	*P*-value
Performance				
Initial BW, lb	758	761	6	0.61
Final BW, lb[2]	1345	1345	15	0.99
DMI, lb/d	24.3	25.2	0.5	0.14
ADG, lb	4.05	4.03	0.09	0.82
Feed: gain[3]	6.06	6.32	0.14	0.11
Carcass characteristics				
Hot carcass weight, lb	847	847	9	0.99
Marbling score[4]	523	543	8	0.04
LM, area in^2.	12.5	12.5	0.3	0.99
12th rib fat, in.	0.59	0.57	0.03	0.59
Yield grade[5]	3.7	3.7	0.2	0.73
Liver abscess, %	8.5	15.0	5.7	0.29

[1]Dietary treatments: NEG = negative dietary cation-anion difference (-16 mEq); POS = positive dietary cation-anion difference (+20 mEq).
[2]Calculated from hot carcass weight, adjusted to a common dressing percentage of 63.
[3]Analyzed as gain:feed, reciprocal of feed conversion.
[4]Marbling score: 400 = $Slight^0$; 450 = $Slight^{50}$; 500 = $Small^0$, etc..
[5]Where yield grade = 2.5 + 2.5(fat thickness, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038(hot carcass weight, lb).

Ingredients were sampled weekly, and feed refusals were analyzed to determine nutrient intake using a weighted composite on a pen basis. Individual steer N retention was calculated using the National Research Council net energy and protein equations (NRC, 1996). Nutrient excretion was determined by subtracting nutrient retention from intake (ASABE, 2005). Total N lost (lb/steer) was calculated by subtracting manure N (corrected for soil N content) and runoff N from excreted N. Percentage of N loss was calculated as N lost divided by N excreted. Animal performance data were analyzed as a randomized complete block design with pen as the experimental unit. The effects of treatment and block were included in the model. Nutrient balance data were analyzed as a completely randomized design with pen as the experimental unit. Stepwise multiple regression analyses 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.

Results

Feedlot Performance

Dry matter intake, ADG, final BW, and HCW were not different ($P > 0.10$) among treatments in either experiment (Tables 1 and 2). Feed efficiency was improved ($P = 0.05$) for cattle consuming NEG diets compared with POS in the WINTER (5.66 and 6.14, respectively) and numerically improved ($P = 0.11$) in the SUMMER (6.06 and 6.32, respectively). Calculated USDA yield grade and LM area tended ($P = 0.10$ and P = 0.08, respectively) to be greater for cattle consuming NEG diets than those consuming POS diets in the WINTER. Marbling score was greater ($P = 0.04$) for the NEG treatment compared with POS in the SUMMER experiment. Liver scores and 12th rib fat depth were not influenced ($P > 0.10$) by DCAD in either experiment. In both experiments, cattle performance was not reduced due to negative DCAD diets; feed conversions improved in the WINTER and numerically improved in the SUMMER.

Nutrient Balance

Nitrogen intake, retention and excretion were similar ($P > 0.10$) among treatments for both experiments (Tables 3 and 4). Amounts of DM, OM and N removed during pen cleaning also were similar ($P > 0.50$) among treatments in both experiments. Amount of N lost was similar ($P = 0.59$) among treatments in the WINTER (28.4 and 30.8 lb for NEG and POS, respectively). Amount of N lost in the SUMMER tended ($P = 0.07$) to be greater for POS compared with NEG (47.3 and 43.0 lb, respectively). The difference in amount of N lost during the SUMMER may be due in part to a numerically greater amount of N intake and excretion for cattle fed the POS diet. Runoff N was not different

($P > 0.10$) among treatments in both experiments and constituted 1.7% of excreted N in the WINTER and 2.2% of excreted N in the SUMMER. Percentage of N lost (N lost divided by N excreted) did not differ ($P > 0.25$) among treatments in both experiments. Percent N lost was 39.1% and 40.8% in the WINTER, and 61.3% and 64.6% in the SUMMER (for NEG and POS treatments, respectively).

Initial soil core pH for pens was greater in the WINTER ($P = 0.04$) for cattle receiving the NEG treatment than those receiving the POS treatment (8.52 and 8.39, respectively). However, final soil core pH in the WINTER was greater in pens with cattle receiving the POS treatment compared with NEG (8.70 and 8.52, respectively). Manure pH in the WINTER experiment was greater ($P < 0.01$) for the POS treatment compared with NEG (8.80 and 8.40, respectively). Initial soil core pH in the SUMMER was greater ($P = 0.04$) for POS compared with NEG, but final soil core pH did not differ ($P = 0.29$) among treatment (8.01 and 8.07 for NEG and POS, respectively). Manure pH in the SUMMER experiment was greater ($P < 0.01$) for POS compared with NEG (8.12 and 7.70, respectively). Differences observed for manure pH and final soil core pH did not correspond with N mass balance. In the WINTER experiment, manure pH, initial soil core pH and final soil core pH did not explain a significant amount of variability ($P > 0.15$) for manure N, N lost or percent N loss. In the SUMMER experiment, 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) where cattle excrete feces, resulting in manure pH being a better indicator of N loss.

Table 3. Effect of dietary treatment on soil core pH, manure pH and nitrogen mass balance during WINTER.[1]

Dietary Treatment[2]:	NEG	POS	SEM	*P*-value
N intake	86.8	89.8	2.2	0.21
N retention[3]	14.2	14.4	0.5	0.74
N excretion[4]	72.7	75.4	2.0	0.21
Manure N	41.4	39.1	6.5	0.73
N run-off	1.09	1.42	0.23	0.18
N lost	28.4	30.8	4.5	0.59
N loss, %[5]	39.1	40.8	5.9	0.78
DM removed	4262	4122	806	0.87
OM removed	495	515	72	0.78
Initial core pH	8.52	8.39	0.06	0.04
Final core pH	8.52	8.70	0.05	<0.01
Manure pH	8.40	8.80	0.06	<0.01

[1]Values are expressed as lb/steer over entire feeding period (196 DOF) unless noted.
[2]Dietary treatments: NEG = negative dietary cation-anion difference (-16 mEq); POS = positive dietary cation-anion difference (+20 mEq).
[3]Calculated using the NRC net protein and net energy equations.
[4]Calculated as N intake – N retention.
[5]Calculated as N lost divided by N excreted.

Table 4. Effect of dietary treatment on soil core pH, manure pH, and nitrogen mass balance during SUMMER.[1]

Dietary Treatment[2]:	NEG	POS	SEM	*P*-value
N intake	81.9	84.6	1.8	0.16
N retention[3]	11.5	11.4	0.28	0.56
N excretion[4]	70.3	73.3	1.7	0.11
Manure N	25.9	24.4	3.3	0.67
N run-off	1.51	1.64	0.39	0.76
N lost	43.0	47.3	2.11	0.07
N loss, %[5]	61.3	64.6	3.7	0.39
DM removed	2399	2599	383	0.61
OM removed	383	380	42	0.93
Initial core pH	8.52	8.70	0.08	0.04
Final core pH	8.01	8.07	0.06	0.29
Manure pH	7.70	8.12	0.07	<0.01

[1]Values are expressed as lb/steer over entire feeding period (196 DOF) unless noted.
[2]Dietary treatments: NEG = negative dietary cation-anion difference (-16 mEq); POS = positive dietary cation-anion difference (+20 mEq).
[3]Calculated using the NRC net protein and net energy equations.
[4]Calculated as N intake – N retention.
[5]Calculated as N lost divided by N excreted.

These data suggest that feedlot performance and carcass characteristics are similar for cattle fed with negative and positive DCAD levels in diets with WDGS. The decrease in soil core and manure pH is likely not enough to decrease N losses in open feedlot pens. Calcium carbonate in the feces and the buffering capacity of soil in feedlot pens appears be great enough to offset the lower urinary pH of cattle fed negative DCAD diets.

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