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TOXIC EFFECTS OF HIGH DIETARY SULFUR ON GROWTH PERFORMANCE OF FEEDLOT CALVES DURING THE EARLY GROWING PHASE

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ABSTRACT: Three levels of dietary sulfur (.17, .22, and .27%, DM basis) were evaluated in an 84-d growing trial involving 108 crossbred steer calves (215 kg). Calves were blocked by weight and randomly assigned within weight blocks to 18 pen (6 steers/pen). The basal diet contained (DM basis): 12% alfalfa hay, 8% sudangrass hay, 63% steam-rolled wheat, 6% yellow grease, 8% cane molasses, and 3% supplement. Dietary sulfur levels were achieved by supplementing the basal diet with 0, .20, or .40% ammonium sulfate. Daily weight gain averaged 1.54 kg/d and was not affected by dietary sulfur level (P > .20). However, DM intake tended to increase (linear effect, P = .15), and feed efficiency decreased (linear effect, P < .05) with increasing dietary sulfur level. Observed daily weight gain was 101, 97, and 98% of expected, based on observed NE intake (quadratic effect, P < .05). We concluded that exceeding a dietary sulfur level of .17% (DM basis) in growing diets for feedlot cattle may have detrimental effects on the partial efficiency of energy utilization for maintenance and/or growth.

Key Words: Sulfur, Cattle, Performance

Introduction

Requirement for dietary sulfur in diets for feedlot cattle has been set at .15% (DM basis, NRC, 1996). Supplementation with sulfates to control calculi, as well as liberal use of feedstuffs that are high in sulfur (e.g., high sulfate molasses and distillers solubles) can result in dietary sulfur levels considerably in excess of this requirement. In finishing diets for feedlot cattle, increasing sulfur levels up to .20% (DM basis) has not been detrimental (Bolsen et al., 1973; Zinn et al., 1997). However, increasing dietary sulfur level from .2 to .25% (DM basis) decreased ADG by 22% and feed efficiency by 18% (Zinn et al., 1997). Increasing dietary sulfur level from .19 to .41% (DM basis) depressed ADG by 35% and feed efficiency by 20% (Bolsen et al., 1973). The influence of moderate excesses in dietary sulfur on performance of steers during the early growing period has not been evaluated. The objective of this study was to evaluate the influence moderate excesses in dietary sulfur level on performance of steer calves fed an 80% concentrate growing diet.

Experimental Procedure

One hundred-eight crossbred steers were blocked by weight and randomly assigned, within weight groupings, to 18 pens (6 head/pen). Pens were 43 m^2 with 22 m^2 overhead shade. The trial was initiated July 24, 1996. Steers were implanted with Synovex-S® (Fort Dodge Animal Health, Fort Dodge, IA) upon initiation of the trial and then again on d 56. Three levels of dietary sulfur (.17, .22, and .27%, DM basis) were evaluated in a randomized complete block design. Composition of experimental diets is shown in Table 1. Diets were prepared at approximately weekly intervals and stored in plywood boxes located in front of each pen. Steers were allowed ad libitum access to feed. Approximately 40% of daily feed consumption was provided in the morning feeding and 60% in the afternoon feeding. Estimates of steer performance were based on pen means. Assuming the primary determinant of energy gain is weight gain, energy gain (**EG**, Mcal/d) was calculated by the equation: $EG = (.0557BW^{.75})ADG^{1.097}$ (NRC, 1984). Maintenance energy expended (Mcal/d, **EM**) was calculated by the equation: $EM = .077BW^{.75}$. The NE_m and NE_g of the diets were obtained by means of the quadratic formula ($x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2c}$) where a = -.41EM, b = .877EM + .41DMI + EG, and c = -.877DMI, and $NE_g = .877NE_m - .41$. The trial was analyzed as a randomized complete block design experiment. Treatment effects were tested for linear and quadratic components by means of orthogonal polynomials (Hicks, 1973).

Results and Discussion

The influence of dietary sulfur level on growth performance is shown in Table 2. Daily weight gain averaged 1.54 kg/d and was not affected by dietary sulfur level (P > .20). However, DMI tended to increase (linear effect, P = .15), and feed efficiency decreased (linear effect, P < .05) with increasing dietary sulfur level. Observed daily weight gain was 101, 97, and 98% of expected, based on observed NE intake (quadratic effect, P < .05).

The influence of dietary sulfur level on growth performance differs depending on the form of supplemental sulfur. Moderately excessive levels of supplementation with elemental sulfur has had little detrimental effect. Pendlum et al. (1976) compared .11, .26, and .44% dietary sulfur in a corn-based finishing diet fed to Holstein steers (elemental sulfur was the supplemental sulfur source). Dietary sulfur level did not influence cattle performance. Thompson et al. (1972) conducted 2 trials comparing the effects of .12 vs .37% dietary sulfur on performance of cattle fed a 90% concentrate corn-based finishing diet (elemental sulfur was the source of supplemental sulfur). In one trial, increased sulfur reduced

DMI, and improved feed efficiency. In the other trial, increased sulfur depressed both ADG and DMI. Rumsey (1978) evaluated the effects of 0, .14, .42, and .98% supplemental sublimed sulfur on performance of steers fed a corn-based all concentrate diet. The basal diet contained .14% sulfur. The addition of .14 or .42% sulfur to the basal diet did not affect ADG, but reduced DMI and enhanced feed efficiency. The authors attributed the improvement in feed efficiency with sulfur supplementation to reduced peak lactic acid accumulation after feeding. However, the addition of .98% sulfur had such a depressing effect on DMI that the treatment was deleted before the trial was completed.

In contrast, when the source of supplemental sulfur was in the sulfate form moderate excesses in sulfur supplementation have had consistent detrimental effects. Elemental sulfur is roughly 35% as available for ruminal microbial growth (Kahlon et al., 1975), and roughly 50% as digestible (Johnson et al., 1971; Fron et al., 1990) as either calcium or ammonium sulfate-sulfur. Qi et al (1993), evaluating sulfur levels in diets for wether goats, observed decreased ADG, DMI and feed efficiency as dietary sulfur was increased beyond .20% (calcium sulfate was the source of supplemental sulfur). Increasing dietary sulfur level from .19 to .41% (DM basis) in steers fed a dry rolled corn-based finishing diet depressed ADG by 35% and feed efficiency by 20%. Increasing dietary sulfur level from .2 to .25% (DM basis) decreased ADG by 22% and feed efficiency by 18% in steers fed a steam-flaked corn-based finishing diet (Zinn et al., 1997).

Implications

The constraints between optimum and excessive levels of dietary sulfur appear to be very narrow. Exceeding a dietary sulfur level of .17% (dry matter basis) in growing diets for feedlot cattle may have detrimental effects on the partial efficiency of energy utilization.

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Table 1. Composition of experimental diets fed to steers

Item	Dietary sulfur, % .17	.22	.27
Ingredient composition, % (DM basis)			
Alfalfa hay	4.00	4.00	4.00
Sudangrass hay	6.00	6.00	6.00
Flaked corn	73.60	73.49	73.38
Yellow grease	4.00	4.00	4.00
Molasses cane	6.00	6.00	6.00
Cottonseed meal	2.00	2.00	2.00
Limestone	1.65	1.65	1.65
Urea	1.20	1.11	1.02
Sodium bicarbonate	1.00	1.00	1.00
Magnesium oxide	.15	.15	.15
Trace mineral salt[a]	.40	.40	.40
Ammonium sulfate		.20	.40
Nutrient composition (DM basis)			
NE, Mcal/kg[b]			
Maintenance	2.26	2.26	2.26
Gain	1.58	1.58	1.58
Crude protein, %	11.8	11.8	11.8
Ether extract, %	7.3	7.3	7.3
ADF, %	6.8	6.8	6.8
Calcium, %	.70	.70	.70
Phosphorus, %	.32	.31	.31
Potassium, %	.75	.75	.75
Magnesium, %	.28	.28	.28
Sulfur, %	.15	.20	.25

[a]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, 1.24%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 92.96%.

[b]Based on tabular values for individual feed ingredients (NRC, 1984) with the exception of supplemental fat, which was assigned $\mathbf{NE_m}$ and $\mathbf{NE_g}$ values of 6.03 and 4.79, respectively.

Table 2. Influence of sulfur level on growth-performance response of feedlot steers and dietary NE (Trial 1)

Item	Dietary sulfur, % .17	.22	.27	SD
Days on test	84	84	84	
Pen replicates	6	6	6	
Live weight, kg[a]				
Initial	211.3	212.2	220.8	10.8
Final	342.4	339.0	349.8	13.5
Weight gain, kg/d	1.56	1.51	1.53	.09
DM intake, kg/d	6.63	6.77	6.94	.33
DM intake/gain[b]	4.26	4.49	4.52	.16
Diet net energy, Mcal/kg				
Maintenance[c]	2.15	2.07	2.09	.05
Gain[c]	1.48	1.40	1.43	.04
Observed/expected diet NE				
Maintenance[c]	1.01	.97	.98	.02
Gain[c]	1.01	.96	.97	.03

[a]Initial and final BW reduced 4% to account for fill.
[b]Linear effect ($P < .05$).
[c]Quadratic effect ($P < .05$).