

Ruminant Nutrition: Beef: Vitamin and Minerals

412 Ruminal degradable sulfur from organic and inorganic sources in beef cattle finishing diets. J. O. Sarturi*, G. E. Erickson, T. J. Klopfenstein, and C. D. Buckner, *University of Nebraska, Lincoln*.

The relationships between ruminal hydrogen sulfide concentration ($[H_2S]$) and ruminal degradable S intake (RDSI), total sulfur intake (TSI) or pH variables were evaluated in beef cattle finishing diets. Ruminally cannulated steers ($n = 5$; BW = 486 ± 39 kg) were assigned randomly in a 5×5 Latin square design and fed once daily during five 21-d periods. Steers were fed a corn control diet (CON), inorganic S source (ammonium sulfate; INORG), organic S source (corn gluten meal; ORG) fed at 9.8 or 23.3%, or wet distillers grains with solubles (WDGS) fed at 50%. Dietary S was 0.20, 0.37, 0.31, 0.46 and 0.50% for CON, INORG, low and high ORG, and WDGS, respectively. A laboratory procedure was developed to estimate RDS coefficients for individual ingredients, and used as base for the RDSI calculations. Samples (1.5 g of DM) were incubated (26 h) in triplicate with 75 mL of ruminal fluid (heifers [$n = 2$; BW = 320 kg] fed 60% corn base diets) and 75 mL of McDougall's Buffer. After incubation, bottles were cooled in ice, centrifuged (18,623 g; 20 min; 4°C), decanted, and the precipitate was dried at 100°C and analyzed for S. Standards containing 25:75, 50:50 and 75:25% of starch: solkaflor were used to estimate incorporated S due to bacterial growth, and subtracted from the other samples based on digestibility coefficients. Statistical analyses were conducted using the GLIMMIX procedure of SAS, with day as a repeated measure for RDSI, pH and $[H_2S]$. The TSI were 21.9, 37.0, 34.0, 50.5 and 54.9 g/d (SEM = 1.89) and RDSI were 16.5, 32.1, 19.9, 24.4 and 36.2 g/d (SEM = 1.06) for CON, INORG, low and high ORG, and WDGS diets, respectively ($P < 0.01$). The RDSI was able to explain 64.9% of the $[H_2S]$ variation through a linear ($y = -34.74 + 2.36 * RDSI$) relationship ($P < 0.01$), whereas TSI explained only 24.4%. When area below pH 5.6 was added to the RDSI model it accounted for 3.5 more percentage units of the $[H_2S]$ variation. Availability of S for ruminal fermentation provides an important tool for ruminal $[H_2S]$ prediction; more than total S intake or ruminal pH.

Key words: hydrogen sulfide, intake, ruminal degradable sulfur

413 Effects of trace mineral injections on measures of growth and trace mineral status of pre-weaned beef calves. J. D. Arthington*¹ and L. J. Havenga², ¹*University of Florida, Range Cattle Research and Education Center, Ona*, ²*Multimin USA Inc., Fort Collins, CO*.

The objective of this experiment was to determine the effects of injectable trace minerals (ITM) on measures of trace mineral status and performance in pre-weaned beef calves. Brahman x Angus beef calves were assigned to treatment in alternating birth order ($n = 75$ calves/treatment). Treatments consisted of 1 mL s.c. of ITM (MultiMin 90; MultiMin USA, Inc., Fort Collins, CO) or 1 mL of sterile saline. The ITM product contained 60, 10, and 15 mg/mL of Zn, Mn, and Cu, as disodium EDTA chelates, and 5 mg/mL of Se, as Na selenite. Treatments were re-administered to all calves 2 additional times before weaning (approximately 100 and 200 d of age) for a total of 3 treatment administrations. Calves were weaned at approximately 250 d of age. Throughout the study, cow and calf pairs grazed summer bahiagrass pastures with free choice access to a salt-based mineral premix containing 14% Ca, 9% P, 24% NaCl, 0.20% K, 0.30% Mg, 0.20% S, 0.005% Co, 0.15% Cu, 0.02% I, 0.05% Mn, 0.004% Se, 0.3% Zn, 0.08% F, and 82 IU/g of vitamin A. Individual calf body

weight was recorded at birth (d 0) and on d 100, 150, 200, and 250 (weaning). Trace mineral status of calves was assessed in liver biopsy samples ($n = 12$ heifers/treatment) collected on d 150, 200, and weaning (d 250). Liver samples were analyzed for concentrations of Co, Cu, Fe, Mn, Mo, Se, and Zn. Individual calf was the experimental unit. Administration of ITM had no impact on calf BW gain (average = 0.79 kg/d; SEM = 0.015). Although bull calves were heavier ($P < 0.001$) at birth compared with heifers (35.4 vs. 30.8 kg; SEM = 0.73), there were no gender x treatment interactions. Trace mineral status of calves was nutritionally adequate for both treatments on all sampling dates; however, administration of ITM resulted in greater ($P \leq 0.02$) overall average concentrations of liver Cu and Se and a lesser ($P = 0.05$) liver Fe concentration compared with saline-injected calves. In summary, injectable trace minerals administered to mineral-adequate, pre-weaned beef calves, provided greater liver Cu and Se concentrations, but did not impact ADG, compared with saline-injected control calves.

Key words: beef, calves, trace minerals

414 Effect of chromium supplementation on finishing Nellore bulls performance, carcass characteristics, and liver abscesses. R. S. Marques¹, A. M. Pedrosa*², C. T. S. Dias¹, L. R. M. Pinto¹, and F. A. P. Santos¹, ¹*University of Sao Paulo, College of Agricultural Sciences, Piracicaba/SP, Brazil*, ²*Embrapa Cattle Southeast, Sao Carlos/SP, Brazil*.

This trial was designed to determine the effects of increasing organic chromium levels on performance of finishing Nellore bulls fed rations containing (DM%) 16.7% sugar cane bagasse, 69.97% fine ground corn, 9.73% soybean meal, 1.01% urea, 2.58% mineral and vitamin mix, and 30mg/kg of monensin. Four treatments were compared: 0; 0.2; 0.4 or 0.6 mg/kg DM of organic chromium. Two hundred and 30 7 Nellore bulls (337 kg initial BW) allotted in 40 pens (10 pens/treatment) were used in a complete randomized blocks design. Parameters evaluated were dry matter intake (DMI), average daily gain (ADG), feed efficiency (ADG/DMI), hot carcass weight (CW), fat thickness (FT), rib eye area (REA) and liver abscesses. Data were analyzed using PROC GLM of SAS. Dry matter intake, average daily gain, feed efficiency, hot carcass weight, fat thickness and rib eye area were not affected by treatments. Incidence of liver abscesses was negligible.

Table 1. Dry matter intake (DMI), average daily gain (ADG), feed efficiency (ADG/DMI), hot carcass weight (CW), fat thickness (FT) and rib eye area (REA)

	Control	Cr, mg/kg DM			P-value	SEM
		0.2	0.4	0.6		
ADG (kg/d)	1.54	1.48	1.50	1.50	0.8889	0.042
DMI (kg/d)	9.41	9.74	9.58	9.69	0.5893	0.179
ADG/DMI	0.165	0.156	0.157	0.158	0.4699	0.014
CW (kg)	277.58	260.49	278.96	279.97	0.1581	6.81
REA (cm ²)	71.27	71.34	70.85	70.38	0.7176	0.761
FT (mm)	5.05	5.24	5.19	5.20	0.9235	0.177

Key words: additives, chromium, feedlot

415 Meta-analysis of the effect of dietary sulfur on feedlot health. C. A. Nichols*¹, V. R. Bremer¹, A. K. Watson¹, C. D. Buckner¹,

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A meta-analysis of University of Nebraska-Lincoln (UNL) finishing trials was conducted to evaluate the effect of dietary sulfur and other dietary components on feedlot health. Health outcomes included polioencephalomalacia (PEM), bovine respiratory disease, infectious pododermatitis (foot rot), and, ruminal tympany (bloat). Likewise, ruminal degradable sulfur (RDS) concentration is proposed as an alternative to S concentration, with degradability assigned to feed ingredients similar to protein degradability. The effect of RDS on PEM was also evaluated. The analysis used Poisson regression to evaluate health records and diet information from 17,080 cattle from 69 feeding trials conducted within an 8 year time period in the UNL research feedlot and included only finishing periods. There was no significant relationship ($P > 0.05$) between dietary sulfur level and footrot ($n = 484$ cases), and, bloat ($n = 21$ cases). An interaction between dietary sulfur and forage NDF ($P < 0.01$) affected the incidence of PEM cases. For a given level of forage NDF, the incidence of PEM increased as dietary sulfur concentration increased in the diet; however, for a given dietary sulfur concentration, the relative risk for PEM decreased as forage NDF increased. Also, in this multivariable model cattle diagnosed with respiratory disease were more likely to be diagnosed with PEM ($P = 0.02$). A significant relationship was detected between RDS and PEM ($P < 0.01$). As RDS as a % of DM increased in the diet, the incidence of PEM increased. Unlike total dietary sulfur, there was no significant interaction between RDS and forage NDF ($P = 0.12$). In this multivariable model, increasing forage NDF decreased the risk for PEM. Conversely, respiratory disease diagnosis increased the risk but the cause and effect are unclear. Increasing total dietary sulfur, or increasing RDS increased the incidence of PEM in feedlot cattle. Model fit and lack of forage NDF interaction support that using RDS is likely a better predictor of PEM.

Key words: distillers grains plus solubles, polioencephalomalacia, sulfur

416 Effect of delaying the feeding of high sulfur diets to feedlot cattle until after adaptation to a finishing diet. M. E. Drenowski* and S. L. Hansen, *Iowa State University, Ames.*

Elevated concentrations of dietary sulfate have been shown to decrease intake and reduce gain of cattle and can lead to a neurological disorder called polioencephalomalacia (PEM). Sulfate is reduced by ruminal bacteria to toxic hydrogen sulfide (H_2S). Both the incidence of PEM and ruminal concentrations of H_2S in feedlot cattle appear to be greatest during the first 30 d on a full finishing diet. We hypothesized that delaying exposure to high sulfate diets until cattle are fully adapted to a high concentrate diet would reduce the peak ruminal H_2S concentration and thus reduce potential for toxicosis. Sixty Angus crossbred steers ($386 \text{ kg SE} \pm 13$) were blocked by weight and randomly assigned to 1 of 12 pens and one of 3 dietary treatments, including 1) a control diet (0.3% sulfur) fed throughout the trial (C), 2) a high S diet (0.6% sulfur) fed throughout the trial (HS), or 3) the control diet fed during the transition period and for the first 28 d of the finishing period then switched to HS diet for the remainder of the trial (DS). Ruminal H_2S concentrations and pH of 2 steers per pen were measured 6 h after feeding on d 1, 7, 14, 28, 35, 42, 56 and 70 of finishing. Ruminal pH did not differ due to treatment ($P = 0.79$) but was greater ($P < 0.05$) on d 56 (5.85) compared with previous days (5.57). Peak H_2S concentra-

tion of DS (3425 ppm) occurred on d 56 (28 d on HS diet) but was lower ($P < 0.05$) than peak H_2S for HS (5288 ppm) which occurred on d 7. Peak H_2S of the C (2583 ppm) occurred on d 7 and did not differ ($P = 0.23$) from the peak of DS but was less ($P < 0.05$) than HS. Sulfur intake (39.3 g/hd) of C at peak H_2S was less ($P < 0.01$) but DM intake (13.0 kg/hd) of C was greater ($P < 0.01$) than DS (66.8 g/hd; 12.7 kg/hd) and HS (65.7 g/hd; 10.8 kg/hd) at peak H_2S . Sulfur and DM intake of DS did not differ ($P > 0.60$) from HS at peak H_2S . These data suggest that potential for toxicosis was reduced by delaying feeding of high S diets until after steers had received a high concentrate finishing diet for 28 d.

Key words: cattle, hydrogen sulfide, sulfur

417 Effects of zinc and copper source and concentration on feedlot performance and carcass characteristics in yearling steers.

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Crossbred steers ($n = 288$; initial BW = $320 \text{ kg} \pm 10.2$) were used in a randomized complete block design to evaluate the effect of source and concentration of Zn and Cu on live performance and carcass characteristics. Steers were blocked by weight and randomly assigned to one of the 4 treatments (8 pens per treatment). Treatments included: 1) 90 ppm of Zn from ZnSO₄ and 15 ppm of Cu from CuSO₄ (Control, 100% sulfate); 2) 67.5 ppm of Zn from ZnSO₄ plus 22.5 ppm of organic Zn and 11.25 ppm of Cu from CuSO₄ plus 3.75 ppm of Cu from organic Cu (Organic, 75% sulfate, 25% organic); 3) 90 ppm of Zn from tetra-basic ZnCl and 15 ppm of Cu from tri-basic CuCl (100% Hydroxy); and 4) 54 ppm of Zn from tetra-basic ZnCl and 9 ppm of Cu from tri-basic CuCl (reduced Hydroxy, 60%). All steers were fed a typical high concentrate steam flaked corn based finishing diet twice daily. Steers were individually weighed on d -1, 0, 35, 70, 104, 173 and 174. On d 175, steers were transported to a commercial abattoir for slaughter. Initial and final BW, average daily gain, dry matter intake, and gain-to-feed were similar ($P > 0.10$) across treatments and averaged 318.9 kg, 586.5 kg, 1.54 kg/hd/d, 8.80 kg/hd/d, and 0.1753, respectively. Furthermore, hot carcass weight, subcutaneous adipose depth, Longissimus muscle area, calculated YG, marbling score and dressing percentage were similar ($P > 0.10$) across treatments. There was a trend ($P < 0.12$) for treatment to affect the likelihood that an individual carcass within each pen would grade USDA average Choice or higher (7.1, 9.7, 19.7, and 16.4% for the Control, Organic, Hydroxy 100, and Hydroxy 60 treatments, respectively). Results suggest that supplementing Zn and Cu from tetra-basic ZnCl and tri-basic CuCl at 60% of the level provided from sulfate or a sulfate-organic mixture will result in similar performance and carcass characteristics. Further research is necessary to determine the response of different amounts of tetra-basic ZnCl and tri-basic CuCl in finishing diets on cattle performance and carcass merit.

Key words: trace mineral source, tetra-basic zinc, tri-basic copper

418 Effects of supplemental copper and Linpro on performance and carcass characteristic of beef heifers.

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Crossbred yearling heifers ($n = 261$; $351 \pm 23 \text{ kg}$ initial BW) were used in a randomized complete block experiment with a 2×2 factorial treatment arrangement to evaluate effects dietary copper (10 or 100 mg/kg

added copper) and Linpro (0 or 10% of diet DM) on feedlot performance and carcass traits. Linpro is an extruded blend of flaxseed and field peas containing added vitamins and minerals (22% CP; 23% fat). Heifers were blocked by initial BW into heavy and light groups and assigned randomly to experimental pens containing 10 or 11 heifers each. Pens ($n = 24$) were assigned randomly to each of the 4 treatments. Cattle were fed once daily and had ad libitum access to feed and water. Basal diets included (DM basis) 35% wet corn gluten feed, 35% dry-rolled corn, 15% pelleted soybean hulls, 10% corn silage, vitamins, and minerals, and provided 14% crude protein, 300 mg/d monensin, 90 mg/d tylosin, 2200 IU/kg vitamin A, 0.7% Ca, and 0.7% K. For Linpro treatments, the extrudate was added at 10% of the diet DM, replacing soybean hulls. Heifers were implanted (Revalor-200), dewormed (Safe-Guard), and vaccinated against common viral and clostridial diseases (Vista 3, Vision 7). Starting 23 d before harvest, zilpaterol was added to the diet for 20 d. Heavy and light blocks were harvested on d 117 and 132, respectively. There were no interactions between levels of copper and Linpro ($P > 0.10$), and copper level had no impact on performance or carcass traits ($P > 0.10$). Cattle fed Linpro treatments consumed less DM than their counterparts fed diets without (13.6 vs 14.1 kg/d; $P < 0.05$) and had greater gain efficiency (0.137 vs 0.129; $P < 0.01$), but there were no effects on ADG ($P > 0.05$). Carcass traits (HCW, LM area, KPH, 12th-rib fat thickness, marbling, and USDA quality and yield grades) were unaffected by diet ($P > 0.10$). Cattle fed Linpro had fewer severe (A+) liver abscesses ($P < 0.05$), but total incidence of liver abscesses was not different ($P > 0.10$). Results indicate that elevated copper levels do not impact performance or carcass traits of finishing cattle. Linpro can be used effectively as an energy source in finishing cattle diets.

Key words: copper, flaxseed, Linpro

419 Chromium supplementation alters the performance and health of feedlot cattle during the receiving period. B. C. Bernhard*¹, R. J. Rathmann¹, D. N. Finck¹, W. Rounds², and B. J. Johnson¹, ¹Texas Tech University, Lubbock, ²Kemin Industries Inc., Des Moines, IA.

Crossbreed steers ($n = 180$; 230 ± 6 kg) were fed during a 56-d receiving period to determine if supplementing chromium (Cr; KemTRACE Chromium Propionate 0.04%, Kemin Industries) would improve feedlot performance and health of newly received cattle. A completely randomized block design (36 pens; 9 pens/treatment; 4 pens/block; 5 steers/pen) was used. Chromium premixes were supplemented to add 0 (Con), 0.1, 0.2, or 0.3 mg/kg of Cr to the total diet on a DM basis. Cattle were weighed every 14 d. Shrunken body weights, ADG, DMI, G:F, and number of times treated for morbidity (treated if rectal temperature $\geq 39.7^\circ\text{C}$) were recorded. Feedlot performance and morbidity data were analyzed as orthogonal contrasts in the MIXED and GLIMMIX procedure of SAS, respectively, with pen serving as the experimental unit. No differences were detected between treatments for BW, ADG, DMI, and G:F through the first 14 d ($P \geq 0.14$). From d 0 to d 28, DMI tended to linearly increase ($P = 0.07$) and ADG increased linearly ($P = 0.04$) as Cr levels increased. During the same period, BW and G:F showed a significant quadratic effect ($P \leq 0.05$) with 0.1 mg/kg being the least desirable and 0.3 mg/kg being the most accelerated. From d 0 to d 56, BW ($P = 0.08$) and DMI ($P = 0.12$) displayed a ten-

dency to increase linearly, and consequently ADG and G:F increased linearly ($P \leq 0.05$) as Cr concentrations increased. Morbidity results showed a tendency ($P = 0.07$) for a linear decrease in the number of head treated at least once for respiratory symptoms as the Cr concentration was increased. The addition of 0.3 mg/kg of Cr resulted in the greatest performance advantages and reductions in the incidences of morbidity; and when specifically compared with the Con displayed an 8 kg improvement in BW ($P = 0.12$), 4.2% increase in G:F ($P = 0.10$), 10.8% enhancement on ADG ($P = 0.04$), and over 18% fewer cattle were treated at least once ($P = 0.05$). Results of this study indicate that supplementation of Cr to the basal diet can have beneficial effects on the performance and health of newly received steers during the first 56 d on feed.

Key words: chromium propionate, receiving cattle, feedlot performance

420 Chromium supplementation alters the glucose and lipid metabolism of feedlot cattle during the receiving period. B. C. Bernhard*¹, N. C. Burdick², R. J. Rathmann¹, D. N. Finck¹, J. A. Carroll², A. N. Loyd², and B. J. Johnson¹, ¹Texas Tech University, Lubbock, ²Livestock Issues Research Unit, USDA-ARS, Lubbock, TX.

Crossbreed steers ($n = 20$; 235 ± 4 kg) were fed 53 d during a receiving period to determine if supplementing chromium (Cr; KemTRACE Chromium Propionate 0.04%, Kemin Industries) would alter the glucose or lipid metabolism of newly received cattle. Chromium premixes were supplemented to add 0 (Con) or 0.2 mg/kg of Cr to the total diet on a DM basis. Cattle were fitted with jugular catheters on d 52. A glucose tolerance test (GTT) and an insulin sensitivity test (IST) were conducted on d 53 by infusing the steers with 1 mL of a 50% glucose solution/kg of BW (Dextrose 50%, Durvet, Inc.) at 0900 h and 0.1 IU of bovine insulin/kg of BW at 1400 h, respectively. Blood samples were collected at -60, -45, -30, -15, 0, 7.5, 15, 30, 45, 60, 90, 120, and 150 min relative to each infusion. Serum was isolated to determine glucose, insulin, and nonesterified fatty acid (NEFA) concentrations. Data were analyzed using the Mixed procedure of SAS specific for repeated measures with each steer serving as the experimental unit and fixed effects of treatment, time, and their interaction. Throughout the GTT no differences were detected in glucose concentrations or pre-infusion insulin concentrations ($P > 0.50$), but insulin concentrations post-infusion tended to be greater for the Cr steers ($P = 0.06$). In addition, NEFA concentrations during the GTT were lower ($P \leq 0.01$) for Cr steers both pre- and post-infusion. During the IST there was no treatment effect on glucose concentrations pre-infusion ($P = 0.38$), while post-infusion glucose concentrations were greater ($P < 0.01$) in the Cr steers. During the same test, there was no treatment effect detected for insulin concentrations ($P > 0.33$), but at 7.5 min there was a trend for the insulin concentrations of the Con steers to reach a higher peak ($P = 0.12$). Concentrations of NEFA were lower ($P < 0.01$) both pre- and post-infusion during the IST for Cr steers. Results of this study indicate that supplementation of Cr to the basal diet can alter insulin sensitivity and lipid metabolism of newly received steers during the first 53 d on feed.

Key words: chromium propionate, receiving cattle, glucose and lipid metabolism