Effect of Copper Level and Zinc Level and Source on Finishing Cattle Performance and Carcass Traits

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Story in Brief

Feedlot performance and carcass differences attributable to combinations of Cu level (12 vs 24 ppm), Zn level (80 vs 320 ppm), and Zn source ($ZnSO_4$ vs AvailaZn) were determined in 160 heifers (BW=698 lb; Trial 1) and 160 steers (BW=751 lb; Trial 2) fed for an average of 140 and 141 d, respectively, at the Willard Sparks Beef Research Center, Stillwater, OK. Copper level elicited a difference in performance with 16% greater daily gain and 15% greater feed efficiency in heifers that consumed 12 ppm Cu from d 0 to 27. However, in the next period, this effect was reversed (ADG 13% greater for 24 vs 12 ppm Cu) suggesting adaptation occurred. Differences in dressing percent attributable to treatment were observed in both trials, but the differences were small (£ 2%) in each instance. The most consistent response that occurred was an increase in indicators of fat deposition with the higher level (i.e., 320 ppm) of Zn. In both Trials, animals fed 320 ppm Zn had greater 12th-rib fat depth and yield grade compared with animals fed 80 ppm Zn. Source of Zn had less influence, although heifers fed Availa Zn had a greater yield grade. The ability of increased Cu level to reduce subcutaneous fat deposition previously reported was not observed with the inclusion of high Zn levels. In our experiments, there appeared to be no advantage to feeding 24 vs 12 ppm Cu. However, steers and heifers fed 320 ppm Zn had numerically greater daily gain and were more efficient than animals fed 80 ppm Zn. In these Trials, source of Zn had little influence on animal performance or carcass merit.

Keywords: Zinc, Copper, Feedlot, Steers

Introduction

Zinc and Cu have been shown to play a major role in disease resistance and immune responsiveness in stressed feeder cattle. Ward and Spears (1997) showed that supplemental Cu (5 mg/kg of DM) increased DMI during the receiving period, which is a critical time for shipping stressed calves. In addition to their positive effects for stressed cattle, Zn and Cu have been shown to influence finishing performance. A summary of 22 feedlot trials evaluating Zn methionine has shown advantages over inorganic sources of Zn (Zinpro Corp., 1994). Zinc methionine was fed to provide an additional 360 mg of Zn whereas the basal ration ranged from 23.8 to 121.8 ppm. No difference in feed intake was observed; however, ADG was increased 3.3% and feed efficiency 4.1% when cattle were fed Zn methionine compared with controls. In addition, % Choice was increased by 8% for cattle fed Zn methionine. In a study comparing zinc sulfate and two levels of Availa[O]Zn (Zinpro Corporation, Eden Prarie, MN), steers fed Availa Zn had 3.6% greater ADG than steers fed $ZnSO_4$ (Zinpro Corp., 1999). In addition, quality grade and marbling were higher for steers receiving Zn from both the 50:50 Availa Zn and Availa Zn diets compared with steers fed $ZnSO_4$. The study suggested that when protein levels are high (11 vs 14%) and implants are used, Zn requirements are elevated. In addition, providing Zn as an organic source improved feed efficiency and quality grade, marbling score, and tended to increase longissimus muscle area.

Less information is available evaluating the effects of Cu on finishing cattle performance and carcass traits. Ward and Spears (1997) investigated the long-term effects of dietary Cu and Mo on performance of cattle during receiving, growing, and finishing phases and on carcass characteristics at harvest. During the finishing phase, Cu-supplemented (5 mg/kg of DM) steers had greater ADG and gain:feed. Copper supplementation increased carcass leanness and muscling without altering marbling. These data suggest that similar to Zn, Cu can improve efficiency of feed utilization and meat quality by feedlot cattle. However, data evaluating the interaction between Zn and Cu are limited. This study was designed to evaluate the effects of Cu level and Zn source and level in finishing cattle diets.

Materials and Methods

Trial 1: One hundred sixty crossbred heifers (BW=317 ± 22 kg) were placed on trial at the Willard Sparks Beef Research Center, Stillwater, OK on November 21, 2000. At processing, heifers were individually weighed, ear tagged, implanted with ComponentÒE-H (Vet Life, LLC, Overland Park, KS), horns tipped as needed, vaccinated with IBR-PI$_3$-BVD-BRSV (BRSV Vac-4, Bayer Animal Health, Shawnee Mission, KS), and treated for control of external and internal parasites (IvomecÒ Plus, Merial Animal Health, Duluth, GA). Heifers were re-implanted on d 85 with ComponentÒE-H and Component®T-H. After weighing and processing, heifers were blocked by weight into two blocks, and randomly assigned to 32 pens (5 head/pen; 16 pens/block). Heifers were fed for 140 d and harvested at Iowa Beef Packers, Emporia, KS.

Trial 2: One hundred sixty crossbred steers (BW=341 ± 18 kg) were delivered to the Willard Sparks Beef Research Center on July 12, 2001. At processing, steers were individually weighed, ear tagged, implanted with Revalor®S (Hoecst Rossel Vet, Summerville, NJ), horn tipped as needed, vaccinated with IBR-PI$_3$-BVD-BRSV (F3Lp, Bayer Animal Health, Shawnee Mission, KS), and treated for control of external and internal parasites (Ivomec®, Merial Animal Health, Duluth, GA). After weighing and processing steers were blocked by weight into two blocks, and assigned randomly to 32 pens (5 head/pen; 16 pens/block). Steers were harvested by respective weight block with the heavy block being fed for 131 d and the light block being fed for 148 d. All steers were harvested by Excel Corp., Dodge City, KS.

For both trials treatments included: 1) 80 ppm $ZnSO_4$, 12 ppm AvailaÒCu; 2) 80 ppm $ZnSO_4$, 12 ppm Availa Cu, and 12 ppm $CuSO_4$; 3) 40 ppm $ZnSO_4$, 40 ppm Availa®Zn, and 12 ppm Availa Cu; 4) 40 ppm $ZnSO_4$, 40 ppm Availa Zn, 12 ppm Availa Cu and 12 ppm $CuSO_4$; 5) 320 ppm $ZnSO_4$ and 12 ppm Availa Cu; 6) 320 ppm $ZnSO_4$, 12 ppm Availa Cu, and 12 ppm $CuSO_4$; 7) 160 ppm $ZnSO_4$, 160 ppm Availa Zn, and 12 ppm Availa Cu; 8) 160 ppm $ZnSO_4$, 160 ppm Availa Zn, 12 ppm Availa Cu and 12 ppm $CuSO_4$. Basal diets (Table 1) were formulated to meet or exceed NRC (1996) nutrient requirements. Basal diets were identical with the exception of supplement formulation, and supplement used for each dietary treatment was the sole difference between diets. Supplement formulation was identical with the exception of Cu level and Zn source and level that were added at the expense of wheat midds in the supplement (Table 2). Monensin (33 mg/kg of the diet) and tylosin (11 mg/kg of the diet) were fed. Cattle were gradually adapted to the final diet by offering approximately 65, 75 and 85% concentrate diets for 7, 7 and 7 d, respectively. Heifers were fed once daily at 0800 and steers were fed twice daily at 0800 and 1400. Diet and ingredient samples were composited by 28-d periods, allowed to air dry, and ground in a Wiley mill to pass a 1-mm screen. Diet and ingredient samples were analyzed for N, ash (AOAC, 1990), and ADF (Goering and Van Soest, 1970). Cattle were weighed individually before feeding once every 28 d throughout the trial. Initial weight was analyzed as taken, and all interim weights were determined using a 4% pencil shrink. Final live weight was calculated by dividing hot carcass weight by a common dressing percentage (Trial 1=64%; Trial 2=63%). Daily feed intake was summed and feed efficiencies (DMI:ADG) were calculated every 28 d. Hot carcass weight was determined following harvest, and carcasses were evaluated after a 24-h chill for subcutaneous fat depth at the twelfth rib, longissimus muscle area, percentage kidney, pelvic, and heart fat, yield grade, marbling score, and quality grade (USDA, 1997).

Cattle performance data were analyzed using PROC MIXED for repeated measures (SAS, 1999). Class variables included in the model as fixed effects were treatment and time period. Weight replicate was also considered as a class variable and was included in the model. Cumulative feedlot performance from d 0 to 29, d 0 to 56, d 0 to 84, d 0 to 112 and d 0 to harvest, and carcass data were analyzed as a randomized complete block design using the GLM procedure of SAS (1999). Treatment and weight replicate were included in the model as class variables. The model included Cu level (12 ppm Cu vs 24 ppm Cu), Zn level (80 ppm Zn vs 320 ppm Zn), and Zn source ($ZnSO_4$ vs Availa Zn); and the appropriate interactions. Pen (n = 4/trt) was considered the experimental unit for all cattle performance data and individual animal was the experimental unit for carcass data. Carcass quality and yield grades as assigned by USDA were examined on an individual animal basis using the Chi-square analysis technique (SAS, 1999).

Table 1. Dry matter and nutrient composition of basal finishing diets

Ingredients	% of diet DM
Rolled Corn	76.50
Cotton seed hulls	10.00
Yellow grease	3.00
Supplement[a]	10.50
Nutrients (DM basis)	
Dry matter, % as fed	87.65
NEm, Mcal/100lbs	97.17
NEg. Mcal/100lbs	61.86
Crude protein, %	13.50
Calcium, %	.52
Phosphorus, %	.39
Potassium, %	.57

[a]Contained (% DM basis): soybean meal 47.7 (50.48), wheat midds (11.73), cottonseed meal (9.52), limestone 38% (8.57), urea (8.10), di-calcium phosphate (4.76), cane molasses (3.81), salt (2.38), rumensin 80 (.18), tylan 40 (.12), vitamin A-30,000 (.11), manganous oxide (.03), and $CuSO_4$, Availa®Cu, $ZnSO_4$, and Availa® Zn were included to meet total dietary requirements

Table 2. Dry matter composition of supplements								
	Diets[a]							
Ingredient[b]	1	2	3	4	5	6	7	8
Soybean Meal	50.46	50.48	50.48	50.48	50.48	50.48	50.48	50.47
Wheat Midds	11.73	11.69	11.52	11.48	11.10	11.05	10.06	10.02
Cottonseed Meal	9.52	9.52	9.52	9.52	9.52	9.52	9.52	9.52
Limestone 38%	8.57	8.57	8.57	8.57	8.57	8.57	8.57	8.57
Urea	8.10	8.10	8.10	8.10	8.10	8.10	8.10	8.10
Cane Molasses	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81
Dical	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76
Salt	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38
Rumensin 80	.18	.18	.18	.18	.18	.18	.18	.18
Tylan 40	.12	.12	.12	.12	.12	.12	.12	.12
Vitamin A 30	.10	.10	.10	.10	.10	.10	.10	.10
Manganous Oxide	.03	.03	.03	.03	.03	.03	.03	.03
CuSO4		.04		.04		.04		.04
Availa Cu	.05	.05	.05	.05	.05	.05	.05	.05
ZnSO4	.16	.16	.08	.08	.79	.79	.40	.40
Availa Zn			.29	.29			1.43	1.43

[a]1=80 ppm $ZnSO^4$, 12 ppm Availa® Cu
2=80 ppm $ZnSO_4$, 12 ppm Availa® Cu, 12 ppm $CuSO_4$
3=40 ppm $ZNSO_4$, 40 ppm Availa® Zn, 12 ppm Availa Cu
4=40 ppm $ZnSO_4$, 40 ppm AvailaÒ Zn, 12 ppm Availa® Cu, 12 ppm $CuSO_4$
5=320 ppm $ZnSO_4$, 12 ppm Availa® Cu
6=320 ppm $ZnSO_4$, 12 ppm AvailaÒ Cu, 12 ppm $CuSO_4$
7=160 ppm $ZnSO_4$, 160 ppm Availa® Zn, 12 ppm $CuSO_4$
8=160 ppm $ZnSO_4$, 160 ppm Availa® Zn, 12 ppm Availa® Cu, 12 ppm $CuSO_4$
[b]Percent of DM

Results and Discussion

Trial 1. No significant (P>.10) Cu level x Zn level x Zn source x period interactions were detected for interim weights, daily gain (ADG), dry matter intake (DMI), or feed:gain (FG). As expected, the effect of period on live weight was significant (P<.001); cattle gained weight as days on feed increased. Similarly, significant differences for period (P<.001) were detected for ADG, DMI, and FG. In general, ADG and FG were negatively affected by period with an increase in performance from d 85 to 112 that can be attributed to re-implanting. There were no interactions for Cu level x Zn level x period, Cu level x Zn source x period, and Zn level x Zn source x period for live weight, ADG, DMI, and FG. A Cu level x period interaction (P=.04) resulted in reduced (P<.05) ADG from d 0 to 27 and an increase (P<.05) in ADG from d 28 to 56. Subsequently, cattle consuming 12 ppm Cu were more (P<.05) efficient from d 0 to 27, but this effect was numerically reversed in the subsequent period. Feed efficiency was also significantly reduced in steers that consumed 24 ppm Cu from d 112 to the end of the feeding period. Ward and Spears (1997) reported a reduction in feed efficiency with Cu supplementation that they attributed to effects of Cu on ruminal fermentation. There were no Zn level or Zn source x period interactions. No differences were observed for cumulative feedlot performance, but FG tended (P=.10) to be effected by a Cu level x Zn level x Zn source interaction. This most likely resulted from the lower (more favorable) FG when 320 ppm $ZnSO_4$ was fed with both 12 and 24 ppm Cu. There were no significant interactions for Cu level x Zn level, Cu level x Zn source, and Zn level x Zn source for final weight, ADG, DMI, and FG. Dry matter intake tended (P=.08) to be depressed by feeding 24 vs 12 ppm Cu from d 0 to 27, but was significantly increased (P=.01) by feeding 320 vs 80 ppm Zn in the same period. Similar to our data, Gaylean et al. (1995) reported numerical increases in DMI for steers supplemented with either $ZnSO_4$ or Zn methionine vs controls and a numerical depression in DMI for steers supplemented with Cu lysine early in the finishing period.

Carcass characteristics were not affected by Cu level x Zn level x Zn source, or by Cu level x Zn level interactions. However, there was a significant interaction for Cu level x Zn source resulting in Availa Zn at 12 ppm Cu, and $ZnSO_4$ and Availa Zn at 24 ppm Cu having greater (P<.05) 12th-rib fat depth and a greater (P<.05) yield grade (YG) compared with $ZnSO_4$ at 12 ppm Cu. Similar effects tended to be observed for 12th-rib fat depth with increases by Cu level (P=.10) and Zn level (P=.06). Similar to our results, Malcolm-Callis et al. (2000) reported quadratic responses in both fat thickness and YG for steers fed 20, 100 and 200 ppm Zn. Interestingly, there was a tendency (P=.08) for an interaction between Zn level and source, resulting in 14.7% greater 12th-rib fat depth in heifers consuming Availa Zn and 320 ppm total Zn. In addition, YG was greater (P=.02) in heifers consuming Availa Zn compared with heifers consuming $ZnSO_4$. There was a tendency (P=.06) for a Zn level x Zn source interaction for dressing percent, and heifers fed 12 ppm Cu had a greater (P=.04) dressing percent than heifers fed 24 ppm Cu.

Trial 2. No significant Cu level x Zn level x Zn source x period or Cu level x Zn level x period interactions were detected for live weight, ADG, DMI, or FG. There was a significant (P=.008) Cu level x Zn source x period interaction for ADG. This generally resulted from greater (P<.05) ADG from d 85 to 112 for steers fed 12 ppm Cu with Availa Zn and steers fed 24 ppm Cu and $ZnSO_4$ compared with steers fed 12 ppm Cu and $ZnSO_4$ and 24 ppm Cu and Availa Zn. From d 112 to the end of the feeding period, this response was reversed. A similar interaction (P=.04) occurred for FG. Steers that consumed Availa Zn at 24 ppm Cu were the most efficient from d 112 to end, whereas steers that consumed Availa Zn at 12 ppm Cu were the least efficient. A Zn level x Zn source x period interaction (P=.03) was detected for live weight, resulting in significant treatment effects at d 84, 112, and at the end of the feeding period. At all three of these interim weights, steers that consumed Availa Zn at 80 ppm level had the lightest live weights, however, no significant differences were detected for ADG, DMI, or FG for the same interaction. There were no (P>.10) Cu level, Zn level, or Zn source x period interactions. In addition, Cu level x Zn level x Zn source and Cu level x Zn level interactions did not occur (P>.10) for cumulative feedlot performance. However, from d 0 to 27, steers that consumed Availa Zn and 12 ppm Cu, and $ZnSO_4$ and 24 ppm Cu had greater (P=.008) ADG and were more efficient (P=.04) than steers that consumed $ZnSO_4$ and 12 ppm Cu, and Availa Zn and 24 ppm Cu. Galyean et al. (1995) reported a Cu lysine x Zn source interaction for ADG and FG during the initial 21 d of a similar finishing trial. Similar patterns were detected for ADG with respect to a Zn level x Zn source interaction. From d 0 to 27 and d 0 to 112, steers that consumed $ZnSO_4$ at 80 ppm and Availa Zn and 320 ppm had greater (P=.04) ADG, and were more (P=.01) efficient on d 0 to 27 than steers that consumed Availa Zn at 80 ppm, and $ZnSO_4$ at 320 ppm.

Reductions in ADG with increasing Zn levels have been reported previously (Malcolm-Callis, 2000); however in our experiment Availa Zn appeared to reduce ADG when 80 ppm Zn was fed, and numerically increase ADG when 320 ppm Zn was fed. In Trial 2, steers that consumed 24 ppm Cu tended (P=.10) to be more efficient than steers that consumed 12 ppm Cu, and steers consuming $ZnSO_4$ tended (P=.08) to be more efficient from d 0 to 84 of the feeding period. Several researchers (Engle and Spears, 2000; Engle and Spears, 2001; Engle et al., 2000) have reported no effect of dietary Cu concentration on performance parameters up to 40 ppm Cu. However, Ward and Spears (1997) reported increases in ADG and feed efficiency attributable to Cu supplementation. Steers consuming 320 ppm Zn tended to have greater ADG (P=.09) and DMI (P=.08) than steers consuming 80 ppm Zn from d 0 to 112.

Carcass characteristics were not affected (P>.10) by a Cu level x Zn level x Zn source interaction. Copper supplementation has been shown to reduce fat deposition (Engle and Spears, 2000; Engle and Spears, 2001; Engle et al., 2000), whereas Zn supplementation has been reported to increase fat deposition (Greene et al., 1988; Spears and Kegley, 1994). In Trial 2, dressing percent tended (P=.06) to be greater for steers consuming 320 ppm Zn at 12 ppm Cu and was significantly greater (P=.03) for steers consuming $ZnSO_4$ at 12 ppm Cu than steers consuming Availa Zn at 12 ppm Cu or $ZnSO_4$ at 24 ppm Cu. Dressing percent was also significantly greater (P=.04) for steers that consumed 12 vs 24 ppm Cu. Twelfth rib fat depth was significantly less (P=.03) for steers consuming Availa Zn at 12 ppm Cu than other treatments and yield grade was significantly greater for steers consuming 320 vs 80 ppm Zn.

Implications

Performance differences attributable to combinations of Cu level, Zn level, and Zn source were not consistent. Copper level elicited a difference in performance with 16% greater daily gain and 15% greater feed efficiency in heifers that consumed 12 ppm Cu from d 0 to 27. This is likely attributable to reductions in ruminal fermentation capability. However, in the next period, this effect was reversed suggesting ruminal adaptation. Differences in dressing percent attributable to treatment were observed in both trials but the differences were small (≤ 2%) in each instance. The most consistent response that occurred was an increase in indicators of fat deposition with the higher level (i.e., 320 ppm) of Zn. In both Trials, animals fed 320 ppm Zn had greater 12th-rib fat depth and yield grade compared with animals fed 80 ppm Zn. Source of Zn had less influence, although heifers fed Availa Zn had a greater yield grade. The ability of increased Cu level to reduce subcutaneous fat deposition previously reported was not observed with the inclusion of high Zn levels.

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