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Abstract

Human diets often contain high levels of saturated fatty acids that can have deleterious health consequences such as obesity, diabetes, and heart disease. In contrast, omega-3 fatty acids, which are essential for human nutrition, are consumed at relatively low levels despite of their positive effects on health. Natural sources of omega-3 fatty acids include fresh legumes, cool-season grasses, flaxseed, and fish oil. In spite of the fact that fresh forages often are a key part of the cattle diet, beef is a relatively poor source of omega-3 fatty acids because of biohydrogenation, the action of microorganisms in the rumen that convert polyunsaturated fatty acids, including the omega-3 fats, into saturated fats. Previous research at Kansas State University has shown that feeding cattle flax-based feeds can increase concentrations of omega-3 fatty acids in beef. Researchers at Colorado State University have reported that elevated levels of dietary copper can inhibit the biohydrogenation process to yield beef with greater proportions of polyunsaturated fatty acids. Our objective was to evaluate whether feeding elevated copper concentrations in conjunction with Linpro (O&T Farms; Regina, Saskatchewan, Canada), a co-extruded blend of field peas and flaxseed, could be used to further improve the levels of omega-3 fatty acids in beef.

Keywords

Cattlemen's Day, 2012; Kansas Agricultural Experiment Station contribution; no. 12-231-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 1065; Beef Cattle Research, 2012 is known as Cattlemen's Day, 2012; Beef; Linpro; Copper; Feedlot cattle performance; Carcass characteristics; Fatty acid

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Influence of Linpro and Dietary Copper on Feedlot Cattle Performance, Carcass Characteristics, and Fatty Acid Composition of Beef

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Introduction

Human diets often contain high levels of saturated fatty acids that can have deleterious health consequences such as obesity, diabetes, and heart disease. In contrast, omega-3 fatty acids, which are essential for human nutrition, are consumed at relatively low levels despite of their positive effects on health. Natural sources of omega-3 fatty acids include fresh legumes, cool-season grasses, flaxseed, and fish oil. In spite of the fact that fresh forages often are a key part of the cattle diet, beef is a relatively poor source of omega-3 fatty acids because of biohydrogenation, the action of microorganisms in the rumen that convert polyunsaturated fatty acids, including the omega-3 fats, into saturated fats. Previous research at Kansas State University has shown that feeding cattle flax-based feeds can increase concentrations of omega-3 fatty acids in beef. Researchers at Colorado State University have reported that elevated levels of dietary copper can inhibit the biohydrogenation process to yield beef with greater proportions of polyunsaturated fatty acids. Our objective was to evaluate whether feeding elevated copper concentrations in conjunction with Linpro (O&T Farms; Regina, Saskatchewan, Canada), a co-extruded blend of field peas and flaxseed, could be used to further improve the levels of omega-3 fatty acids in beef.

Experimental Procedures

The study was conducted as a randomized complete block experiment with a 2 × 2 factorial treatment arrangement. Supplementation consisted of dietary copper (10 or 100 ppm added copper) and Linpro (0 or 10% of diet, dry basis). Linpro is an extruded blend of flaxseed and field peas containing 12% α-linolenic acid (the primary omega-3 fat in plants) with added vitamins and minerals (22% crude protein, 23% fat). We used 261 crossbred yearling heifers (775 ± 51 lb initial body weight), which were blocked by weight into heavy and light groups and assigned randomly to experimental pens containing 10 or 11 heifers each. Twenty-four feedlot pens were assigned randomly to each of the 4 treatments. We fed cattle once daily with free-choice access to feed and water. Basal diets included (dry matter basis) 35% wet corn gluten feed; 35% cracked corn; 15.8% pelleted soybean hulls; 10% corn silage, vitamins, and minerals; and provided 14% crude protein, 300 mg/day Rumensin (Elanco Animal Health, Greenfield, IN), 90 mg/day Tylan (Elanco Animal Health), 1000 IU/lb vitamin A, 10 IU/lb vitamin E, 0.1% added Na, 0.15% added Cl, 0.10 ppm Co, 0.6 ppm I, 0.25 ppm Se, 60 ppm Mn, and 60 ppm Zn (Table 1). For Linpro diets, the extrudate was added at 10% of dry matter, replacing soybean hulls. Heifers were implanted (Revalor-200; Merck Animal Health, Summit, NJ), dewormed (Safe Guard, Merck Animal Health), and vaccinated against common viral and clostridial diseases (Vista 3 and Vision 7;

Merck Animal Health). Starting 23 days before harvest, Zilmax (Merck Animal Health) was added to the diet for 20 days. We harvested the heavy and light blocks on day 117 and 136, respectively, in a commercial abattoir where we collected slaughter data. After a 24-hour chill period, we evaluated the animals for fat thickness over the 12th rib; percentage kidney, pelvic, and heart fat; ribeye area; marbling score; and USDA yield and quality grades. Furthermore, we obtained loin samples from one side of three carcasses randomly selected from each pen. Data were statistically analyzed using the MIXED procedure of SAS (Version 9.1; Cary, NC) with Linpro, copper, the interaction between Linpro and copper, and block as fixed effects; pen nested within Linpro, copper, and block as the random effects; and pen as the experimental unit.

Results and Discussion

During this trial we observed no negative effects on the health (toxicity) of our heifers fed with the high level of copper, which is reflected on the feedlot performance presented in Table 2. No effect of copper or interaction between Linpro and the level of copper ($P > 0.20$) was found. Final weight and average daily gain were not different for heifers fed deits with and without Linpro ($P > 0.20$), but dry matter intakes were less for heifers fed Linpro compared with those fed the control diets ($P = 0.03$; 30.0 and 31.10 lb/day, respectively). Efficiency (gain:feed) and net energy for maintenance (NEm) and growth (NEg) were therefore greater when we fed Linpro ($P < 0.01$).

We found no effects ($P > 0.10$) of Linpro, copper, or the interaction between Linpro and copper on carcass traits (Table 3). Numerically, final weights were 12 lb lighter for cattle fed 100 ppm copper compared with those fed 10 ppm supplemental copper. We found an average of 64.0% of dressed yield and longissimus muscle area of 92.2 in^2. The mean marbling score was 516, which represents a moderate level of intramuscular fat.

In Table 4 we present a summary of fatty acid profiles of beef. No significant interactions occurred between Linpro and the level of copper with respect to beef composition. Linpro had no effect on total fat, saturated fat, or monounsaturated fat ($P > 0.10$), but, as expected from previous research, polyunsaturated and omega-3 fatty acids were greater ($P < 0.01$) for heifers fed Linpro. Additionally, the ratio of omega-6 and omega-3 fatty acids decreased from 7.03 in beef from heifers fed the control diet to 3.98 in that of heifers fed Linpro. We observed no effect of copper on the proportions of saturated and unsaturated fatty acids in beef ($P > 0.20$).

Implications

Copper was ineffective as a strategy for improving assimilation of polyunsaturated fatty acids into beef. Linpro can be used effectively as an energy source and to modify tissue concentrations of omega-3 fatty acids in beef.

Table 1. Experimental diets without (Control) and with supplemental Linpro containing 10 or 100 ppm of added copper (Cu)

	Control		Linpro	
Item	10 Cu	100 Cu	10 Cu	100 Cu
Ingredients, %				
Dry rolled corn	35.0	35.0	35.0	35.0
Wet corn gluten feed	35.0	35.0	35.0	35.0
Corn silage	10.0	10.0	10.0	10.0
Soybean hulls	15.8	15.8	5.71	5.68
Linpro	-	-	10.0	10.0
Supplement[a]	4.16	4.19	4.29	4.32
Composition (%)				
Dry matter	67.16	67.16	67.61	67.62
Crude protein	14.71	14.71	15.65	15.65
Ether extract	2.70	2.70	4.76	4.76
Neutral detergent fiber	28.02	28.00	23.42	23.40
Calcium	0.63	0.66	0.65	0.63
Phosphorus	34.12	34.12	34.10	34.10
Potassium	0.88	0.89	0.77	0.78

[a] Formulated to provide 10 or 100 ppm Cu, 300 mg/day Rumensin and 90 mg/day Tylan (Elanco Animal Health, Greenfield, IN), 1000 IU/lb vitamin A, 10 IU/lb vitamin E, 0.1% added Na, 0.15% added Cl, 0.10 ppm Co, 0.6 ppm I, 0.25 ppm Se, 60 ppm Mn, and 60 ppm Zn.

Table 2. Performance of crossbred heifers fed Control or Linpro diets containing 10 or 100 ppm of added copper (Cu)

	Control		Linpro			*P*-value[a]		
Item	10 Cu	100 Cu	10 Cu	100 Cu	SEM	L	C	L×C
Initial weight, lb	776	774	778	771	3.95	0.70	0.34	0.50
Final weight, lb	1279	1268	1296	1274	10.8	0.27	0.15	0.52
Average daily gain, lb	4.03	3.98	4.19	4.03	0.077	0.20	0.21	0.64
Dry matter intake, lb	31.09	31.09	30.42	29.54	0.463	0.03	0.29	0.28
Feed:gain	7.52	7.69	7.09	7.14	0.002	<0.01	0.41	0.47
NEm, Mcal/100 lb	91.5	89.8	96.0	95.5	1.00	<0.01	0.30	0.58
NEg, Mcal/100 lb	61.6	60.2	65.7	65.2	0.86	<0.01	0.31	0.58

[a] L: effect of Linpro; C: effect of copper level; L×C: Interaction between Linpro and copper level.

Table 3. Carcass traits of crossbred heifers fed Control or Linpro diets containing 10 or 100 ppm added copper (Cu)

	Control		Linpro			*P*-value[a]		
Item	10 Cu	100 Cu	10 Cu	100 Cu	SEM	L	C	L×C
Hot carcass weight, lb	818	810	832	816	7.32	0.20	0.13	0.57
Dressed yield, %	64.0	63.9	64.1	64.0	0.31	0.79	0.79	0.79
Ribeye area, in2	14.1	14.5	14.5	14.2	0.21	0.88	0.69	0.10
Kidney, pelvic, and heart fat, %	2.6	2.7	2.6	2.6	0.08	0.64	0.74	0.55
12th rib fat, in.	0.87	0.67	0.67	0.75	0.07	0.37	0.41	0.13
Marbling score	508	520	523	512	17.9	0.89	0.97	0.54
Prime, %	4.7	9.1	9.2	6.1	3.55	0.85	0.86	0.31
Choice, %	89.1	75.8	76.9	75.8	6.01	0.33	0.25	0.33
USDA yield grade	2.66	2.49	2.66	2.64	0.10	0.43	0.32	0.47
Liver abscesses, %	10.9	19.7	12.3	7.6	4.31	0.23	0.66	0.13

[a] L: effect of Linpro; C: effect of copper level; L×C: interaction between Linpro and copper.

Table 4. Total saturated, monounsatured, polyunsaturated, omega-3, and omega-6 fatty acids in loin samples from crossbred heifers fed Control and Linpro diets containing 10 or 100 ppm added copper (Cu)

	Control		Linpro			*P*-value[a]		
Fatty acids, %	10 Cu	100 Cu	10 Cu	100 Cu	SEM	L	C	L×C
Saturated	3.17	3.45	3.43	3.11	0.329	0.90	0.97	0.37
Monounsaturated	3.71	4.08	3.93	3.57	0.399	0.72	0.99	0.38
Polyunsaturated	0.36	0.39	0.45	0.42	0.019	<0.01	0.94	0.17
Omega-3	0.041	0.047	0.086	0.081	0.003	<0.01	0.89	0.15
Omega-6	0.301	0.317	0.341	0.318	0.015	0.19	0.83	0.20
Omega-6:omega:3	7.27	6.78	4.02	3.93	0.125	<0.01	0.03	0.13
Total fatty acids	7.24	7.92	7.80	7.10	0.743	0.87	0.99	0.37

[a] L: effect of Linpro; C: effect of copper level; L×C: interaction between Linpro and copper.