Feedstuffs Reprint

Chromium affects beef production, health

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By **BRADLEY J. JOHNSON, BRYAN C. BERNHARD** and **RYAN J. RATHMANN***

ONE of the most important microminerals for a beef feedlot quite possibly might be the least utilized; however, recent discoveries in chromium research indicate enormous nutritional and financial benefits.

With feed costs at record levels, finding new ways to lower costs and enhance profitability on the feedlot is crucial in today's economy.

Feed accounts for approximately 70% of total production costs in the beef industry and is the single largest variable cost in beef production systems (Perry, 1995). Research indicates that adding chromium to today's feedlot rations helps alleviate the financial burden associated with production.

Chromium is an essential nutrient in animal nutrition, and for many years, typical rations for domesticated animals were thought to contain adequate levels of chromium. Over the years, suggestions that chromium intake is generally low have sparked interest in further researching this element.

Preliminary studies displayed beneficial effects of chromium supplementation on the biological function, health and production of animals and people. Chromium supplementation has been a popular topic in the swine industry for many years and recently gained popularity in the cattle feeding industry. In the 1990s, multiple papers were published concluding that chromium could have beneficial effects on the performance, health and blood metabolites of stressed feeder cattle.

*Dr. Bradley J. Johnson is a professor and the Gordon W. Davis regent's chair in meat science and muscle biology in the department of animal and food sciences at Texas Tech University. Bryan Bernhard is currently a doctoral student in animal nutrition at Oklahoma State University. Dr. Ryan J. Rathmann is an assistant professor in animal and food sciences at Texas Tech University.

Chromium sources

There are many organic and inorganic sources of chromium that have been the subject of research over the past several decades.

Currently, chromium propionate (CrPro) is the only Food & Drug Administration-permitted organic source of chromium available for use in cattle. Other organic sources of chromium that have been researched over the years include a high-chromium yeast, chromium methionine (CrMet), chromium picolinate, chromium nicotinic acid complex (CrNic) and chelated chromium. Chromium chloride is an inorganic form of chromium and has also been researched in the past.

The actual bioavailability of these different sources is still relatively unknown, but generally, organic sources have displayed more advantages in production, immune response and blood metabolites, suggesting that they are more bioavailable.

Initial research investigating chromium revealed inconsistent results from trial to trial. These variations in results were attributed to disparities in the chromium status of the cattle prior to initiation of the study, the basal chromium level of the diet, the level of chromium supplementation and the bioavailability of the source of chromium supplementation (Spears, 2000).

Recent studies utilizing CrPro have consistently revealed beneficial performance results, primarily gain and efficiency advantages, as shown in Table 1.

Performance response

Since FDA granted its permission in 2009, numerous studies have highlighted the

1. Effect of CrPro on enhancing adipogenic differentiation of intramuscular and subcutaneous adipocytes

Adipocytes	Intramuscular	Subcutaneous
AMPK-α	+	-
GLUT 4	+	-
PPAR-γ	+	-
Lipid droplets	↑↑	↑–

2. Effect of CrPro on enhancing adipogenic differentiation of muscle cells

Musele cells	
Chromium	Increases myotube size ↑
Chromium	Number of myotubes ↑
GLUT4	No change
GLUT4/GAPDH	↓

1. Literature review: Effect of chromium supplementation on the performance of beef cattle

Citation	ADG	DMI	Gain:feed	Chromium source
Chang and Mowat, 1992	Incr.	—	Incr.	High-chromium yeast
Mowat et al., 1993	Incr.	—	Incr.	High-chromium yeast or chelated chromium
Moonsie-Shageer and Mowat, 1993	Incr.	Incr.	—	High-chromium yeast
Kegley and Spears, 1995	—	—	—	Chromium chloride, High-chromium yeast or CrNic
Chang et al., 1995	—	—	—	Chromium yeast or chromium chloride
Kegley et al., 1997	Incr.	—	—	CrNic
Kegley et al., 2000	—	—	—	CrMet
Rounds et al., 2011a	—	Decr.	Incr.	CrPro
Rounds et al., 2011b	Incr.	Incr.	Incr.	CrPro
Brown et al., 2011	Incr.	—	Incr.	CrPro
Bernhard et al., 2012	Incr.	—	Incr.	CrPro

2. Effects of chromium supplementation on the overall live performance of steers during the receiving period (Bernhard et al., 2012).

	Chromium inclusion ---level, mg/kg[1]---		-Chromium effect-	
Item	0	0.3	Gain	%
Initial bodyweight, kg	231	230	—	—
Final bodyweight, kg	319	327	8	2.5***
ADG, kg/day	1.57	1.74	0.17	10.8*
DMI, kg/day	6.67	7.04	0.37	5.5***
Gain:feed	0.237	0.247	0.01	4.2**

[1]Dry matter basis.
*P = 0.04; **P = 0.10; ***P $\leq$ 0.14.

3. Effects of chromium supplementation on the overall morbidity of steers during the receiving period (Bernhard et al., 2012)

	Chromium inclusion ---level, mg/kg[1]---		-Chromium effect-	
Morbidity	0	0.3	Change	%
Cattle treated at least once, %	25.85	7.48	Decrease	18.37*
Cattle treated at least twice, %	8.49	2.37	Decrease	6.12**
% of treatments within the first 14 days	26	5	Decrease	21*

[1]Dry matter basis.
*P $\leq$ 0.05; **P > 0.15.

performance and production benefits of CrPro.

In a study conducted by Bernhard et al. (2012), CrPro caused a linear increase in dry matter intake (DMI) and average daily gain (ADG) by day 28 when supplemented at 0.0, 0.1, 0.2 and 0.3 mg/kg of chromium. This equated to a 12.6% increase in ADG in favor of chromium supplementation when comparing steers on the highest chromium supplementation level (0.3 mg/kg) to the control steers.

Over the entire trial (56 days), ADG increased linearly as a result of gain:feed increasing linearly as chromium concentrations were increased, with 0.3 mg/kg of chromium being the most favorable treatment level. The highest chromium dose (0.3 mg/kg) tended to improve efficiency when compared directly to the control steers; this created a 10.8% increase in ADG in favor of the 0.3 mg/kg chromium-supplemented steers, as shown in Table 2 (Bernhard et al., 2012).

In 2011, Rounds et al. (2011a) reported that CrPro supplementation reduced DMI of bulls fed for 211 days. With similar ADG, the group fed 0.2 mg/kg CrPro displayed a 4.9% improvement in feed efficiency compared to non-supplemented bulls. Rounds et al. also concluded that 0.6 mg/kg of CrPro supplementation caused a significant reduction in ADG, implying that optimal supplementation concentrations were around 0.2-0.4 mg/kg.

In another study conducted by Rounds et al. (2011b), CrPro supplementation of 0.15 mg/kg increased DMI in bulls over the course of 189 days. CrPro supplementation of 0.15 or 0.30 mg/kg improved ADG and feed efficiency in bulls compared to non-supplemented bulls.

Brown et al. (2011) reported that CrPro supplementation of 0.1 or 0.2 mg/kg produced no differences in DMI during the receiving or finishing period. They also reported that CrPro supplementation improved ADG and feed:gain by 3.25% and 4.70%, respectively, during the 226-day trial.

While all steers were receiving zilpaterol hydrochloride at the end of the feeding period, cattle supplemented with CrPro displayed a linear improvement in ADG and feed:gain (Brown et al., 2011).

Economics of health

Animal health issues have a significant effect on the overall profitability of the feedlot because of high treatment costs, negative performance results and decreased carcass trait values.

Research confirms the importance of health in the feedlot, implying that the prevention of sickness offers the highest return on investment.

Schneider et al. (2009) studied the economic impact of bovine respiratory disease (BRD) in feedlot cattle. Comparing cattle that had never been treated for BRD with cattle that were treated once, twice and three or more times, a decrease was observed in performance and carcass merit, with a decline of $23.23, $30.15 and $54.01 in carcass value, respectively (Schneider, 2009).

Iowa State University research also studied these relationships and the effect health status has on feedlot performance and carcass traits (Busby et al., 2008). Cattle receiving one medical treatment gained 5% more slowly than healthy cattle, and cattle treated two or more times gained 8.4% more slowly than healthy cattle. In addition, 71.5% of the never-treated cattle graded Choice or better, compared to 53.4% of the cattle that were treated two or more times.

The Texas A&M Ranch-to-Rail database that compares performance and carcass merits showed similar economic results (McNeil, 1996 and 2001). For the 1991-95 period, healthy cattle averaged $92.26 more profit per head than sick cattle did. The Ranch-to-Rail data for 2000-01 showed even more dramatic economic improvements, with healthy cattle averaging $151.18 more profit per head.

Morbidity, mortality

Feedlot cattle are often faced with immune challenges that demand an increase in energy efficiency in order to prevent sickness. Research demonstrates that CrPro has a consistent and repeatable response that optimizes insulin sensitivity, which increases the opportunity to maximize feedlot performance and profits.

Bernhard et al. (2012) reported that the number of steers treated at least once tended to linearly decrease with increasing CrPro concentrations.

Supplementation with 0.3 mg/kg of CrPro reduced the number of steers treated at least once by 18.37% compared to non-supplemented steers (Table 3).

Following an immune challenge with lipopolysaccharide (LPS) infusion, control steers displayed greater behavioral signs of sickness compared with steers supplemented with 0.2 mg/kg of CrPro. The CrPro-supplemented steers also lost less weight during the immune challenge period. By day 8 post-LPS challenge, CrPro-supplemented steers had gained weight (compared to pre-challenge bodyweight), while the non-supplemented steers had not recovered to their pre-challenge bodyweight.

Collectively, this implies that chromium supplementation enhances the acute phase response of steers to an LPS challenge, which may expedite recovery (Burdick at el., 2011).

This is an extremely important point since BRD and other illnesses have been estimated to cost the U.S. beef industry close to $1.5 billion annually.

Brown et al. (2011) noted that extremely harsh weather conditions (cold and wet) resulted in significant death loss; however, newly received steers that were supplemented with CrPro experienced a decrease in mortality of 6.8% compared to the steers that were not supplemented.

Rectal temperature

Elevated body temperatures following a pathogen invasion is a crucial step to removing infectious microorganisms.

Dinarello (1996) and Steiger et al. (1999) proved that pro-inflammatory cytokines, including tumor necrosis factor-alpha (TNF-a) and interleukin-6 (IL-6), stimulate increases in the rectal temperature of cattle.

Following administration of LPS, rectal temperature increased in CrPro-supplemented and non-supplemented steers, but the change in rectal temperature from baseline values was greater in control steers (Burdick at el., 2011).

These data indicate that supplementing CrPro to newly received feedlot cattle has a beneficial effect in modulating the febrile response. Subsequently, this quick return to normal body temperatures resulted in sustained DMI in receiving cattle. Consistent DMI is one of the most challenging aspects of starting newly received cattle.

Cortisol, cytokines

Cortisol is known to negatively regulate immune function during stressful times. Following LPS administration, serum cortisol concentrations did not differ between control and CrPro-supplemented steers (Burdick et al., 2011).

Normally, the acute phase response will result in pro-inflammatory cytokines being secreted within one to four hours post-challenge. Based on these results, Burdick et al. (2011) concluded that CrPro supplementation did not affect serum concentrations of interleukin-4, but IL-6, TNF-a and interferon-gamma were greater in CrPro-supplemented steers post-LPS administration compared to non-supplemented steers.

It appeared that supplementation with CrPro mitigated the immune response, as evidenced by changes in pro-inflammatory cytokines. Taken together, the immune challenge data suggested that CrPro supplementation had very positive effects on the ability of stressed cattle to recover from a health challenge.

Carcass response

Very few carcass data have been published in regard to chromium supplementation. Most studies over the years have been conducted during the receiving period, and very few have collected carcass results.

Rounds et al. (2011b) did show that CrPro supplementation improved carcass weight of bulls by more than 5% compared to non-supplemented bulls.

Tokach et al. (2011) conducted research to further investigate the effects of CrPro on enhancing the adipogenic differentiation of bovine muscle-derived cells and intramuscular (IM) and subcutaneous (SC) adipocytes. The data (Figures 1 and 2) indicated that a time-dependent treatment of CrPro increased GLUT4 levels in IM adipocyte cultures. These GLUT4 data indicated that a treatment of CrPro may regulate the early phase of IM adipocyte differentiation. The level of GLUT4 was steadily increased in both IM and SC adipocytes during the late phase of adipocyte differentiation.

However, bovine satellite cells treated with CrPro in this study showed no effect on GLUT4 mRNA expression and had a decreased GLUT4/GAPDH protein ratio in a dose-dependent fashion. The variation in these results between adipocytes and muscle satellite cells indicated that CrPro has differential effects on different tissues.

In essence, CrPro decreased GLUT4 protein levels in muscle cell cultures, suggesting that those cells have an increased efficiency of glucose uptake due to exposure to increased levels of CrPro. In contrast, each of the two adipogenic lines had opposing responses to CrPro. It appeared that CrPro had the most stimulative effect of GLUT4 response in the IM adipocytes compared to SC adipocytes.

This suggests opportunities to potentially augment marbling in beef cattle fed CrPro during the finishing period. Future work still needs to be conducted to determine the effects of chromium on other carcass parameters like marbling score, dressing percentage, yield grade, etc., especially when utilized in conjunction with growth-promoting agents.

Conclusion

It is well known in the modern beef industry that growth-promoting agents such as implants and beta-adrenergic agonists will continue to play a crucial role in efficient beef production.

Although performance improvements have been made, the beef industry still loses approximately $1.5 billion each year to health-related issues. Complementing implants and beta-adrenergic agonists and reducing the costs associated with health are two areas of cattle feeding that could benefit the most from supplementation of microminerals such as chromium.

Recent studies show that CrPro can offer more consistency in improving the performance and health of cattle than other previously studied chromium sources. This cost-effective micronutritent potentially can decrease health risks while markedly improving feedlot performance.

Chromium can potentially influence the marbling capabilities of beef cattle, which could improve the quality of beef when complementing implants and beta-adrenergic agonists. Most important, though, evidence suggests that chromium improves the health of feedlot cattle and recovery rates if the cattle are exposed to an immune challenge.

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