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Chromium Propionate Supplementation Increases Pregnancy Rate by Artificial Insemination in Beef Cows[1]

INTRODUCTION

Chromium (Cr) is an essential nutrient that potentiates the action of insulin-sensitive glucose uptake.[2] Insulin and glucose have critical metabolic roles in reproduction.[3,4,5] Previous research with the effects of Cr supplementation on reproductive performance are limited in scope, but have demonstrated positive impacts on reproductive performance of dairy cows.[6,7,8] No research has been conducted investigating the effects of Cr supplementation on the reproductive biology of beef cows.

KEYWORDS: Chromium propionate, reproduction, artificial insemination, beef cows

MATERIALS & METHODS

Animals and Treatments

This experiment was conducted across nine cow/calf operations within the Virginia Department of Corrections System and enrolled 953 lactating primiparous and multiparous Angus-based cows (age = 5.3 ± 0.61 yr, days post-partum ± 79.9 ± 4.61 d, and body condition score (BCS) = 5.1 ± 0.05). Within location, cows were sorted by BCS, age, and days post-partum on day -92 and allocated to a total of 26 pastures so that average BCS, age, and days post-partum were similar among groups. Pastures were then assigned to one of the following treatments: 1) CON (Control, n = 16 pastures), 484 beef cows supplemented with free choice mineral; or 2) TRT (Treatment, n = 16 pastures), 471 beef cows supplemented with free choice mineral containing 1.4 g/cow daily chromium propionate (KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA). Cows were maintained in tall-fescue-dominated pastures with *ad libitum* forage allowance, free choice mineral and water throughout the experimental period. The experimental period started 92 days before calving and extended until weaning.

Artificial Insemination and Breeding

All cows were enrolled in a 7-day CO-Synch + controlled internal drug release (CIDR) timed-artificial insemination (TAI) protocol from day -10 to 0. Specifically, cows received 100 ug of gonadotropin-releasing hormone (Factrel®; Hikma Pharmaceuticals USA Inc., Berkeley Heights, NJ) plus a CIDR containing 1.38 g of progesterone (P4; Zoetis Services LLC, Parsippany, NJ), on day -10 cows received 25 mg of prostaglandin F2α (Lutalyse®; Zoetis Services LLC, Parsippany, NJ). The CIDR was removed on day -3. Sixty-six hours following CIDR removal, cows received a second 100-ug injection of gonadotropin-releasing hormone and artificial insemination (day 0). All injections were given intramuscularly in the neck region of the cows. Estrus detection patches (Estrotect®; Mark L. Anderson, LLC, Spring Valley, WI) were applied on day -3 to all cows, and the occurrence of estrus was recorded at TAI. Estrus was defined as the removal of >50% of the rub-off coating on the patch. Multiple experienced AI technicians (n = 8) and semen from different *Bos Taurus* sires (n = 5) were used across locations but balanced among treatments within each location. Approximately 10 days after TAI, cows were exposed to natural service with bulls that successfully passed a breeding soundness exam. Cow pregnancy rate by TAI was accessed with transrectal ultrasonography by the presence of a viable fetus (Easi-Scan Veterinary Ultrasound Scanner, IMV Imagining, Rochester, MN) and was determined between days 55 and 65 after TAI. A second pregnancy diagnosis was performed between days 85 and 95 to determine final pregnancy rate. Cow body weight and body condition score were recorded at the beginning of the experiment, at the initiation of the TAI protocol, at both pregnancy diagnoses, and at the end of the experiment, when calves were weaned.

Feed Sampling and Health Management

Samples of forage and mineral supplements were collected at the beginning of the experiment, at the first pregnancy diagnosis, and at the end of the experiment, then pooled together for nutritional analysis by a commercial laboratory (Dairy One Forage Laboratory, Ithaca, NY). Grass samples were dried for 48 h at 55°C in forced-air ovens for DM calculation prior to submitting for nutritional analysis. The average forage nutritional analysis across all locations is presented in Table 2. Water was offered *ad libitum* for the entirety of both experiments. At the beginning of the TAI protocol, all cows were vaccinated against respiratory viruses (BOVILIS® VISTA® 5 L5; Intervet Inc., Madison, NJ). At the final pregnancy diagnosis, beef females deemed pregnant received a booster vaccine to prevent Leptospira Hardjo Bacterin (SPIROVAC®; Zoetis Services LLC, Parsippany, NJ).

Statistical Analysis

Quantitative and binary data were analyzed with the MIXED and GLIMMIX procedures of SAS® (version 9.3 SAS/STAT; SAS Inst., Inc., Cary, NC), respectively. Data were analyzed using pasture as the experimental unit. Model statements contained the effect of treatment, and included pasture (treatment x location), cow (pasture), and location as random variables. Body condition score, cow body weight, weight change, and calf weaning weight were analyzed using the MIXED procedure of SAS with treatment as a fixed effect. Estrus expression, TAI pregnancy rate, and overall pregnancy rate were analyzed using the GLIMMIX procedure of SAS with the effects of treatment and all interactions. Results are reported as least square means and separated using LSD. Significance was set at $P \leq 0.05$, and tendencies were determined if $P > 0.05$ and $P \leq 0.10$.

RESULTS & DISCUSSION

Cow performance and descriptive statistics are presented in Table 1. Initial cow age, days postpartum, initial and final body weight, and body condition score were similar ($P > 0.10$) among treatments. Mineral disappearance did not differ among treatments (165.5 g/head/day and 152.9 g/head/day for CON and TRT, respectively). Estrus expression tended ($P = 0.08$) to be greater for cows supplemented with chromium propionate than CON (Figure 1). Further, TAI pregnancy rate was greater for cows consuming chromium propionate than CON (55.2% vs. 49.9% for TRT and CON, respectively; $P = 0.04$; Figure 2). Final pregnancy rate did not differ among treatments ($P > 0.92$; Figure 2). Calf birth weight, 95-day weight, and weaning weight were similar for CON and TRT ($P > 0.05$; Table 1).

The association between body condition score and pregnancy success in beef cattle has been well-established.[9,10,11] Beef cows maintained in a body condition 5 or 6 at the end of the postpartum interval have a greater likelihood of returning to estrus sooner than those at a body condition score 4.[10,12] Throughout this experiment, cows were allowed access to pastures that met or exceeded nutrient requirements. The average body condition score of cows at TAI was 5.4 and was not influenced by treatment.

Mechanisms for improvements in estrus expression and TAI pregnancy rate with chromium propionate supplementation are likely multifactorial. The post-partum period is characterized as a period of stress for beef cows. Chromium requirements increase during stress; serum cortisol was decreased by chromium supplementation in feeder steers.[13] Although not evaluated in the present study, perhaps chromium propionate aided in recovery during the post-partum period. Moreover, during the process of uterine involution following parturition, smooth muscle turnover can increase insulin resistance through a reduction in expression of Glut-4 transporters, driven by myostatin.[13] Chromium propionate has been documented to increase expression of Glut-4 transporters in bovine muscle cells,[15] perhaps offsetting some insulin resistance that may occur with smooth muscle turnover during the early postpartum period. Furthermore, insulin and glucose availability increase estradiol production; estradiol plays a key role in facilitating sperm transport and conceptus survival.[16] Although estradiol production was not measured in the present study, estrus expression was increased in cows supplemented with chromium propionate, likely driven by an increased balance of insulin and glucose from chromium.

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Table 1. Cow Performance

Item[1]	Control	Treatment	SEM	*P*-Value
Age, yrs	5.4	5.3	0.61	0.917
Days postpartum, d	79.2	79.9	4.61	0.910
Mineral intake, $g^{-1}hd^{-1}d$	165.5	152.9	22.62	0.698
Body weight day 0, kg	515.7	515.6	15.11	0.995
Body weight day 65, kg	558.5	551.4	14.50	0.734
Body weight day 95, kg	580.8	594.6	13.51	0.489
Body weight day 285, kg	574.2	570.9	14.32	0.872
Body condition score, day 0	5.1	5.1	0.05	0.351
Body condition score, day 65	5.4	5.4	0.09	0.828
Body condition score, day 95	5.3	5.3	0.10	0.963
Body condition score, day 285	5.1	5.2	0.10	0.735
Calf Performance				
Birth weight, kg	33.1	32.8	0.65	0.769
Body weight, day 95, kg	102.5	102.1	4.52	0.952
Weaning weight, kg	268.1	271.9	6.74	0.691

[1] 1)Control, free choice mineral supplementation, 113 g/head/day formulated consumption (n = 464 cows; 16 pastures, experimental units); or 2) Treatment ,free choice mineral supplementation, 113 g/head/day formulated consumption containing 1.4 g/cow daily of chromium propionate (n = 464 cows; 16 pastures, experimental units KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA).

Table 2. Nutrient values of forage samples pooled across location

Item[1]	Control	Treatment
Dry matter, %	5.4	5.3
Crude protein, %	79.2	79.9
ADF, %	165.5	152.9
aNDF, %	515.7	515.6
NFC, %	558.5	551.4
TDN, %	580.8	594.6
ME, Mcal,kg	574.2	570.9
Chromium, %	5.1	5.1

Wet chemistry analysis by Dairy One Forage Laboratory, Ithica, NY. [1]1) Control, free choice mineral supplementation, 113 g/head/day formulated consumption (n = 464 cows; 16 pastures, experimental units); or 2) Treatment, free choice mineral supplementation, 113 g/head/day formulated consumption containing 1.4 g/cow daily of chromium propionate (n = 464 cows; 16 pastures, experimental units KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA).

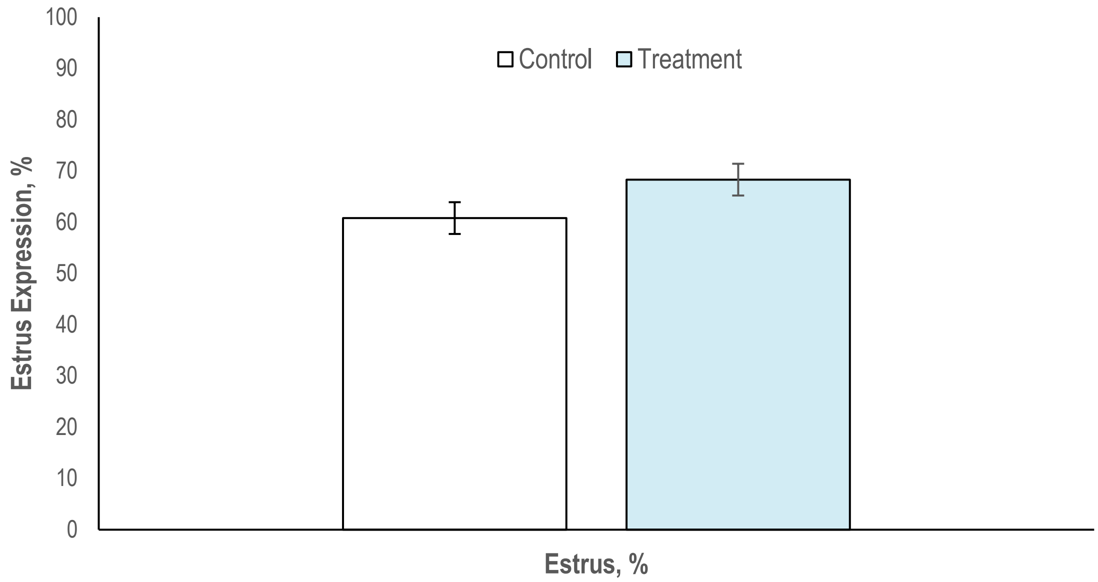

Figure 1. Estrus expression of beef cows supplemented with chromium propionate during the peripartum period through weaning. 1) Control, free choice mineral supplementation, 113 g/head/day formulated consumption, (n = 464 cows; 16 pastures, experimental units); or 2) Treatment, free choice mineral supplementation, 113 g/head/day formulated consumption, containing 1.4 g/cow daily of chromium propionate (n = 464 cows; 16 pastures, experimental units KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA). Estrus detection based on activation of Estrotect® (Mark L. Anderson, LLC, Rockway Inc., Spring Valley, WI) breeding indicator at the day of fixed-time artificial insemination. Treatment, $P = 0.08$.

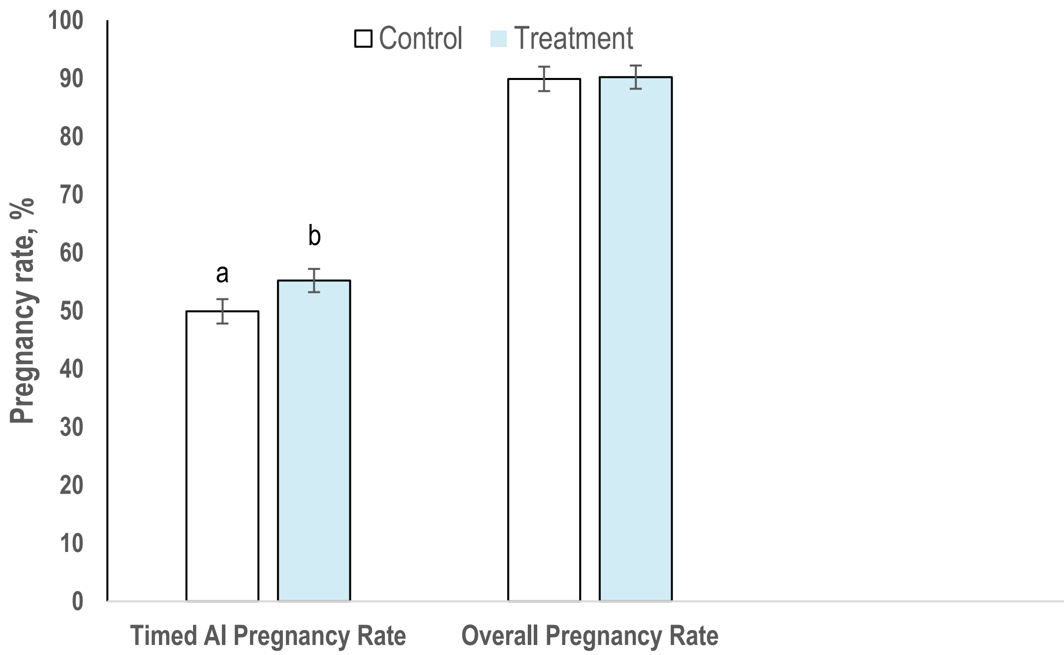

Figure 2. Reproductive performance of beef cows supplemented with chromium propionate from the peripartum period though weaning. 1) Control, free choice mineral supplementation, 113 g/head/day formulated consumption, (n = 464 cows; 16 pastures, experimental units); or 2) Treatment, free choice mineral supplementation, 113 g/head/day formulated consumption, containing 1.4 g/cow daily of chromium propionate (n = 464 cows; 16 pastures, experimental units KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA). [a,b] different superscripts denote the difference between treatments; Treatment, P = 0.045.

CONCLUSIONS

This is the first study documenting the effects of chromium propionate supplementation on reproductive performance of beef cows. Cows in the present study were maintained in a well-managed herds; body condition score throughout the experiment was adequate and t cows grazed pastures that met or exceeded nutrient requirements. Supplementing 1.4 g/cow daily chromium propionate during the peripartum period through weaning increased conception rate to timed artificial insemination by 10.6% and tended to increase estrus activity of beef cows prior to breeding. These findings are likely attributed to the biological effects that chromium has on insulin-dependent glucose uptake in the post-partum beef cow.

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