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Ovarian Follicle Diameter and Corpus Luteum Volume of Beef Cows Enrolled in Fixed-Time Artificial Insemination While Receiving Chromium Propionate Supplementation[1]

INTRODUCTION

Chromium (Cr) is an essential nutrient that potentiates the action of insulin-sensitive glucose uptake.[1] Insulin and glucose have critical metabolic roles in reproduction.[2,3,4] 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.[5,6,7] 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 AND METHODS

Animals and Treatments

This experiment was conducted at the Virginia Tech-Kentland Beef Unit. Lactating, multiparous Angus-based commercial cows (n = 62; age = 7.2 ± 0.61 year, days post-partum = 80.8 ± 4.61 d, and initial body weight = 528.6 ± 16.21 kg) were enrolled in the study. Approximately 63 days prior to breeding, cows were stratified by calving date and body weight and randomly assigned to one of the following treatments: 1) CON (Control, n = 30), individual supplementation of 1kg/head/daily of a corn gluten/soy hull pellet with mineral and vitamin fortification; 2) TRT (Treatment, n = 32), individual supplementation of 1kg/head/daily of a corn gluten/soy hull pellet with mineral and vitamin fortification formulated to provide 1.4 g/cow daily chromium propionate (KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA). Throughout the study, cows remained in a single pasture equipped with feed bunks capable of delivering individual supplement intake (SmartFeed®, C-Lock, Inc., Rapid City, SD).

Artificial Insemination and Breeding

All cows were enrolled in a 7-day CO-Synch + controlled internal drug release (CIDR) timed-AI (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. All cows were inseminated on day 0 by the same technician, using semen from multiple *Bos Taurus* sires (n = 3), equally distributed between treatments. Approximately 10 days after TAI, cows were exposed to natural service with bulls that successfully passed a breeding soundness exam. Cow body weight and body condition score were recorded at the beginning of the experiment, at the start of the TAI protocol, and at pregnancy diagnosis on day 35.

Determination of Follicle Size, Corpus Luteum Volume, and Blood Sampling

Blood samples from the jugular vein were collected from each cow on days -17, -10, -7, 0, and 7 into blood collection tubes containing freeze-dried sodium heparin (Vacutainer®, 10 mL; Becton, Dickinson & Company, Franklin Lakes, NJ). Plasma samples were centrifuged at 2,400 g for 15 minutes at 4ºC and analyzed for P4 using radioimmunoassay (RIA) kits (Coat-A-Count; Diagnostic Products Corporation, Los Angeles, CA). The assay kit was previously validated for bovine serum[8] using an assay volume of 100 µl. The intraassay coefficient of variation was 0.67%. All samples were run as singletons in a single assay with a 0.1 ng/mL sensitivity.

Statistical Analysis

Quantitative and binary data were analyzed respectively with the MIXED and GLIMMIX procedures of SAS® (version 9.3 SAS/STAT; SAS Institute Inc., Cary, NC). Cow was the experimental unit. Estrus expression and timed artificial-insemination pregnancy rate were analyzed using the GLIMMIX procedure of SAS with the effects of treatment and all interactions. Body condition score, body weight, weight change, follicle size, corpus luteum volume, and progesterone concentration, with the fixed effect of treatment, were analyzed using the MIXED procedures of SAS. 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 average daily gain were similar ($P > 0.10$) among treatments. By experimental design, supplement intake was similar ($P > 0.1$) for CON and TRT cows, with both reaching the target intake of 1 kg/head daily (Table 1). Estrus expression did not differ between CON and TRT cows ($P > 0.1$). Although not statistically significant, there was a numerical increase in timed-AI pregnancy rate for cows supplemented with chromium propionate compared with CON cows (81.2% vs 55.1% ± 20.1, $P = 0.685$; Table 1). Follicle diameter was similar on day -10 and -3 and was significantly ($P = 0.028$) larger on day 0 (Timed-AI) for TRT cows compared with CON (Figure 1). In addition, the volume of the CL increased on day 7 post-TAI for cows that consumed chromium propionate compared with CON (Figure 2; $P = 0.03$). Circulating P4 concentration was increased ($P = 0.02$) on day 7 post TAI for TRT cows. Furthermore, the ratio of CL volume to circulating P4 was increased ($P = 0.001$) for TRT cows compared with CON.

Chromium propionate supplementation was associated with increased ovulatory follicle size in the present experiment. Previous studies have shown that heifers ovulating follicles smaller than 10.7 mm in diameter have reduced pregnancy rates compared to those with 12.88 mm or larger follicles.[9] Larger follicles produce more estradiol and contain more TCA cycle intermediates than smaller follicles.[10] Consequently, larger follicles are associated with developing superior oocytes, better suited for producing viable embryos.

In the present experiment, chromium propionate supplementation resulted in cows ovulating larger dominant follicles at TAI and greater CL volume 7 days later. A larger CL volume is associated with greater circulating P4 concentrations.[11] These findings are consistent with results observed in dairy cattle supplemented with chromium propionate in a short-duration, high-dose strategy, which increased the P4 produced per average unit of CL volume compared to CON cows.[7]

The present study also showed increased circulating P4 on day 7 for chromium propionate supplemented cows, corresponding with greater CL volumes. Previous research has shown that a rapid increase in circulating P4 levels post-ovulation is critical for embryo survival and pregnancy maintenance.[12,13] The increased glucose availability in chromium propionate-supplemented cows could potentially enhance CL development and P4 secretion by providing more energy to support luteal function, leading to more P4 production during the early stages of pregnancy. Thus, the increased CL volume and concentration of P4 observed in this study may explain the numerically increased pregnancy rates for the chromium propionate supplemented cows on day 35. Although a numerical increase in AI pregnancy rate was observed in cows supplemented with chromium propionate, the experiment was not designed to detect differences in pregnancy rate and had fewer animals.

Table 1. Cow performance and demographics.

Item[1]	Control	Treatment	SEM	*P*-Value
Cows, n	30	32		
Cow age, yr	7.4	7.2	0.61	0.91
Days postpartum, d	81.3	80.8	4.61	0.95
Supplement intake, kg/d	1.22	1.03	0.21	0.53
Body weight, day 0, kg	526	529	16.21	0.89
Body weight, day 125, kg	548	551	13.50	0.64
Body weight, day 165, kg	563	575	11.41	0.29
Average daily gain, kg/d	0.22	0.29	0.03	0.52
Timed-AI pregnancy rate, %	55.1	81.2	16.8	0.33

[1]Control, (n = 30) individual supplementation of 1 kg/head/day of corn gluten/soy hull (50:50) pelleted feed fortified with vitamins and minerals, or 2) Treatment, (n=32) individual supplementation of 1 kg/head/day of corn gluten/soy hull (50:50) pelleted feed fortified with vitamins and minerals and formulated to provide 1.4 g/ cow daily of chromium propionate (KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA).

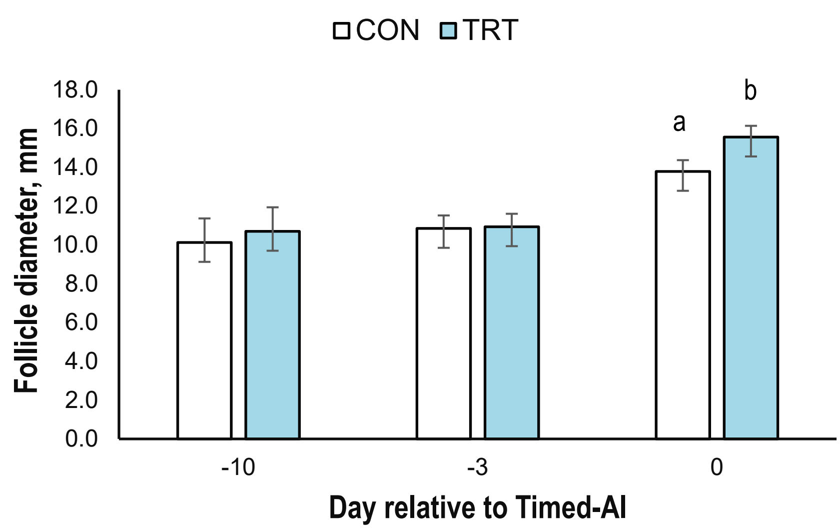

Figure 1. Diameter of the largest follicle on days relative to fixed-time artificial insemination (TAI) of beef cows exposed to a 7-day CO-Synch+CIDR synchronization protocol and receiving a supplement containing chromium propionate. CON (Control, n = 30) individual supplementation of 1 kg/head/day of corn gluten/soy hull (50:50) pelleted feed fortified with vitamins and minerals; TRT (Treatment, n=32) individual supplementation of 1 kg/head/day of corn gluten/soy hull (50:50) pelleted feed fortified with vitamins and minerals and formulated to provide 1.4 g/cow daily of chromium propionate (KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA).
[a,b] different superscripts denote the difference between treatment groups; Trt*day *P* = 0.028.

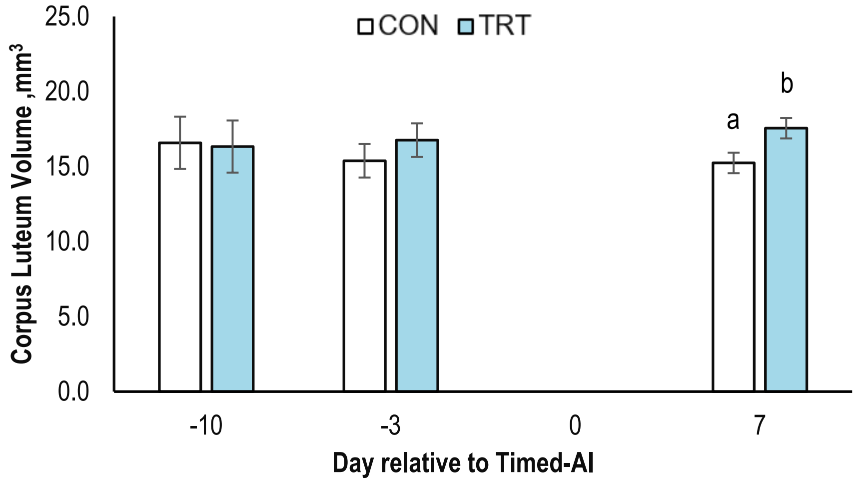

Figure 2. The volume of Corpus Luteum (CL) present on days relative to fixed-time artificial insemination (TAI) of beef cows exposed to a 7-day CO-Synch+CIDR synchronization protocol and receiving chromium propionate supplementation.
CON (Control, n = 30) individual supplementation of 1 kg/head/day of corn gluten/soy hull (50:50) pelleted feed fortified with vitamins and minerals; TRT (Treatment, n=32) individual supplementation of 1 kg/head/day of corn gluten/soy hull (50:50) pelleted feed fortified with vitamins and minerals and formulated to provide 1.4 g/cow daily of chromium propionate (KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA).
[a,b] different superscripts denote the difference between treatments; Trt*day *P* = 0.038.

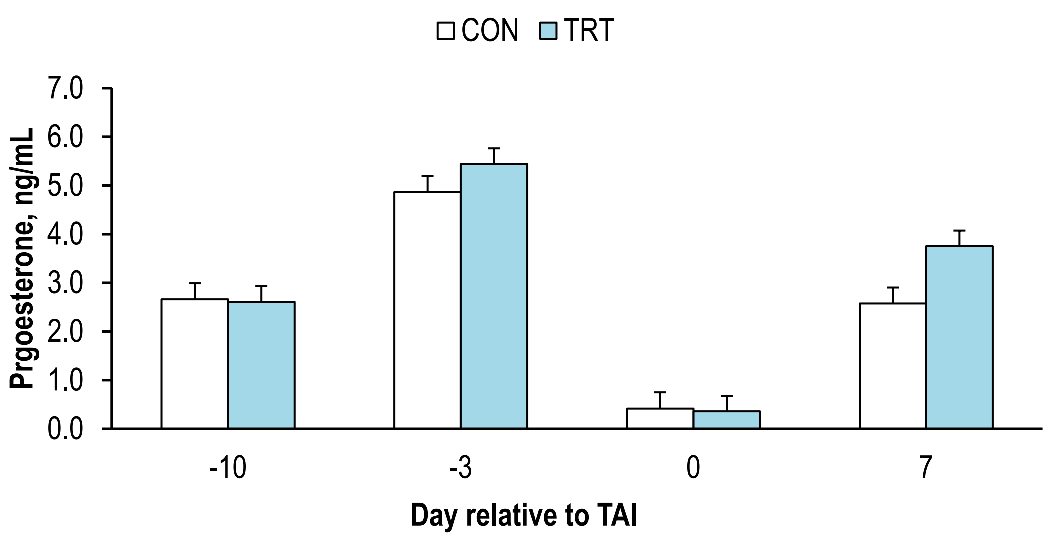

Figure 3. The concentration of progesterone on days relative to fixed-time artificial insemination (TAI) of beef cows exposed to a 7-day CO-Synch+CIDR synchronization protocol and receiving chromium propionate supplementation.
CON (Control, n = 30) individual supplementation of 1 kg/head/day of corn gluten/soy hull (50:50) pelleted feed fortified with vitamins and minerals; TRT (Treatment, n=32) individual supplementation of 1 kg/head/day of corn gluten/soy hull (50:50) pelleted feed fortified with vitamins and minerals and formulated to provide 1.4 g/cow daily of chromium propionate (KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA).
treatment*day *P* = 0.021.

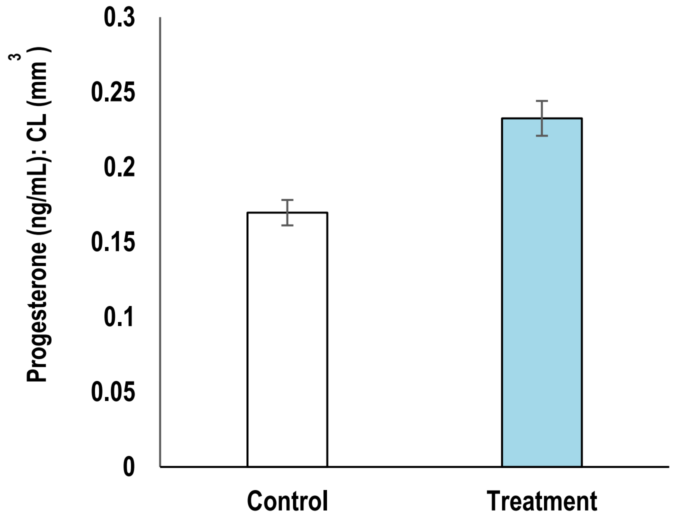

Figure 4. The progesterone ratio to average corpus luteum (CL) volume (mm^3) of beef cows exposed to a 7-day CO-Synch+CIDR synchronization protocol and receiving chromium propionate supplementation. Control, (n = 30) individual supplementation of 1 kg/head/day of corn gluten/soy hull (50:50) pelleted feed fortified with vitamins and minerals; TRT (Treatment, n=32) individual supplementation of 1 kg/head/day of corn gluten/soy hull (50:50) pelleted feed fortified with vitamins and minerals and formulated to provide 1.4 g/cow daily of chromium propionate (KemTRACE® Chromium 0.4%, Kemin Industries, Inc., Des Moines, IA). Treatment, *P* = 0.002.

Conclusions

This is the first study documenting the effects of chromium propionate supplementation on reproductive physiology of beef cows in a well-managed herd. Cows in the present study were in adequate body condition and were maintained on pastures that met or exceeded nutrient requirements. Supplementing 1.4 g/cow daily chromium propionate increased dominant follicle size, corpus luteum volume, and progesterone concentration, likely attributed to the biological effects that chromium has on insulin-dependent glucose uptake in the post-partum beef cow.

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References

1. Vidlund, T., Currin, J., Clark, S., Steward, J. L., Craun, H., Mitchell, M., Wolpert, B., Redifer, T., Mercadante, V. R. G., 231 Ovarian follicle diameter and corpus luteum volume of beef cows enrolled in fixed-time artificial insemination while receiving chromium propionate supplementation, Journal of Animal Science, Volume 102, Issue Supplement_3, September 2024, Pages 286–287.
2. Schwarz, K., and W. Mertz. 1959. Chromium (III) and the glucose tolerance factor. Arch. Biochem. Biophys. 85:292-295.
3. Medina, C. L., Nagatani, S., Darling, T.A., Bucholtz, D.C., Tsukamura, H., Maeda, K. and Foster, D.L. 1998. Glucose Availability Modulates the Timing of the Luteinizing Hormone Surge in the Ewe. Journal of Neuroendocrinology. 10: 785-792.
4. Diskin, M. G., D. R. Mackey, J. F. Roche, J.M. Sreenan. 2003. Effects of nutrition and metabolic status on circulating hormones and ovarian follicle development in cattle. Animal Reproduction Science. 78:345-370.
5. Butler, S. T., S. H. Pelton, and W. R. Butler. 2004. Insulin increases 17β-estradiol production by the dominant follicle of the first postpartum follicle wave in dairy cows. doi:10.1530/rep.1.00079.
6. Ferguson, 2013. J. Dairy Sci. 96:(E-Supplement 1):127.
7. Yasui et al., 2014 J. Dairy Sci. 97:6400-6410.
8. Soffa, D. R., J. W. Stewart, A. G. Arneson, N. W. Dias, V. R. G. Mercadante, R. P. Rhoads, and M. L. Rhoads. 2023. Reproductive and lactational responses of multiparous dairy cattle to short-term postpartum chromium supplementation during the summer months. JDS Commun. 4:161–165. doi:10.3168/jdsc.2022-0287.
9. Kirby, C. J., M. F. Smith, D. H. Keisler, and M. C. Lucy. 1997. Follicular Function in Lactating Dairy Cows Treated with Sustained-Release Bovine Somatotropin1. J. Dairy Sci. 80:273–285.
10. Perry, G. A., M. F. Smith, A. J. Roberts, M. D. MacNeil, and T. W. Geary. 2007. Relationship between size of the ovulatory follicle and pregnancy success in beef heifers1. J. Anim. Sci. 85:684–689.
11. Hessock, E. A., J. L. Edwards, F. N. Schrick, R. R. Payton, S. R. Campagna, A. B. Pollock, H. M. Clark, A. E. Stokes, J. L. Klabnik, K. S. Hill, S. R. Roberts, M. G. Hinson, and S. E. Moorey. 2023. Metabolite abundance in bovine preovulatory follicular fluid is influenced by follicle developmental progression post estrous onset in cattle. Front. Cell Dev. Biol. 11:1156060.
12. Vasconcelos, J. L. M., R. Sartori, H. N. Oliveira, J. G. Guenther, and M. C. Wiltbank. 2001. Reduction in size of the ovulatory follicle reduces subsequent luteal size and pregnancy rate. Theriogenology. 56:307–314.
13. Perry, G. A., M. F. Smith, M. C. Lucy, J. A. Green, T. E. Parks, M. D. MacNeil, A. J. Roberts, and T. W. Geary. 2005. Relationship between follicle size at insemination and pregnancy success. Proc. Natl. Acad. Sci. 102:5268–5273.
14. Lopes, A. S., S. T. Butler, R. O. Gilbert, and W. R. Butler. 2007. Relationship of pre-ovulatory follicle size, estradiol concentrations and season to pregnancy outcome in dairy cows. Anim. Reprod. Sci. 99:34–43.