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Chromium propionate supplementation during the peripartum period interacts with starch source fed postpartum: Production responses during the immediate postpartum and carryover periods

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ABSTRACT

Forty-eight multiparous cows were used in a randomized complete block design experiment with a 2 × 2 factorial arrangement of treatments to determine the interaction between chromium propionate (CrPr) supplementation and sources of corn varying in ruminal starch fermentability on production responses during the postpartum (PP) and carryover periods. During the peripartum period (28 d before expected parturition until 28 d PP), diets were top-dressed (20 g/d) with either CrPr (KemTRACE Chromium Propionate, Kemin Industries, Des Moines, IA; 8 mg of Cr/cow per day) or control (Con; ground corn). At parturition, cows were randomly assigned to corn treatment within CrPr and Con treatments: dry corn (DC) or high-moisture corn (HMC). Treatment combinations (CrPr/DC, CrPr/HMC, Con/DC, and Con/HMC) were fed from parturition until 28 d PP (treatment period). Cows were fed a common diet to evaluate potential carryover effects of the treatment diets from 29 to 84 d PP (carryover period). The CrPr and corn treatments interacted over time to affect yield of 3.5% fat-corrected milk (FCM) during both the treatment and carryover periods. The CrPr/HMC treatment combination tended to increase FCM compared with Con/DC and Con/HMC by 28 d PP (57.4 vs. 48.6 and 48.5 kg/d, respectively) and increased FCM compared with Con/DC by 42 d PP (59.2 vs. 44.8 kg/d). The CrPr tended to increase milk yield (55.4 vs. 51.9 kg/d) regardless of corn source during the carryover period after treatment ceased. Daily and cumulative DMI were not affected by treatment during the PP period, but CrPr and corn treatments interacted over time to affect daily DMI during the carryover period; DMI was generally higher for CrPr/HMC, lower for Con/DC, and intermediate for CrPr/DC and Con/HMC from 29 to 84 d PP. Supplementation of CrPr throughout the peripartum period interacted with starch source in PP diets over time to affect production responses that were sustained after treatment application ceased.

Key words: chromium propionate, starch fermentability, transition period, early lactation

INTRODUCTION

Chromium (Cr) has been reported to increase insulin sensitivity of tissues in cattle (Subiyatno et al., 1996; Hayirli et al., 2001; Sumner et al., 2007) and other species (Matthews et al., 2001; Clodfelder et al., 2005; Wang and Cefalu, 2010). A decrease in insulin sensitivity, which could lead to increased fat mobilization, has been described in dairy cattle around parturition (Bell, 1995). Excessive net lipolysis in the peripartum period can result in hepatic steatosis, ketosis, and reduced feed intake (Allen and Piantoni, 2013). The reduction in feed intake during the peripartum period might be caused by a satiety signal from hepatic oxidation of the consistent supply of fatty acids to the liver (Allen et al., 2005). Strategies that increase insulin sensitivity, such as Cr supplementation, might decrease lipolysis through the transition from pregnancy to lactation, benefiting feed intake and milk yield (Hayirli et al., 2001; McNamara and Valdez, 2005). Although Cr supplementation increased milk yield in those and other experiments (Smith et al., 2005; Sadri et al., 2009; Soltan, 2010), effects on productive performance have been inconsistent; Cr supplementation did not affect milk yield (Yang et al., 1996; Yasui et al., 2014) or feed intake (Yang et al., 1996; Sadri et al., 2009; Soltan, 2010; Yasui et al., 2014) during this period in other experiments.

Inconsistent effects on feed intake and milk production might be partially related to variation in starch fermentability of rations among studies. Fermentability of starch sources fed to dairy cattle is highly variable and affects both feed intake of lactating cows (Allen, 2000) and insulin response to a glucose challenge (Bradford and Allen, 2007). Propionate production by rumen microbes increases with increasing ruminal starch fermentability (Hobson, 1972). Because propionate is hypophagic (Forbes, 2007) and its hypophagic effects

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are elevated when cows are in a lipolytic state (Allen, 2014), a reduction in lipolysis in the peripartum period might especially benefit cows offered rations containing highly fermentable starch. We hypothesized that production response to Cr propionate supplementation through the peripartum period will be dependent upon starch source varying in ruminal fermentability fed during the postpartum (**PP**). Our objective was to determine if diets containing corn grain sources varying in ruminal starch fermentability affect production responses to chromium propionate supplementation differently in the PP period.

MATERIALS AND METHODS

Animal Housing and Care

All experimental procedures were approved by The Institutional Animal Care and Use Committee at Michigan State University (East Lansing). The experiment began on December 9, 2009, and finished on October 7, 2010. Cows were housed in individual tiestalls for the duration of the experiment. Cows were fed once daily (1000 h) at 110% of expected intake throughout the entire experiment. After parturition, cows were milked twice daily at 0400 and 1400 h. Standard reproduction and herd health checks and breeding practices were maintained throughout this study.

Design and Treatments

Forty-eight multiparous Holstein cows at the Michigan State University Dairy Cattle Teaching and Research Center were used in a randomized complete block design with a 2 × 2 factorial arrangement of treatments with 12 cows per treatment. Cows were blocked by date of parturition (within 90 d), BCS (up to 1 unit difference using a 5-point scale, where 1 = thin and 5 = fat; Wildman et al., 1982), and previous lactation 305-d mature-equivalent milk production (within 5,500 kg). At 28 ± 3 d prepartum, cows within a block were randomly assigned to Cr treatment based upon expected parturition date. During the peripartum period (28 ± 3 d before expected parturition until 28 ± 3 d PP) half of the cows (n = 24) were top-dressed daily (20 g/d) with chromium propionate (**CrPr**; KemTRACE Chromium Propionate, Kemin Industries, Des Moines, IA; 8 mg of Cr/cow per day) and the other half (n = 24) with control (**Con**; ground corn). At parturition, cows were randomly assigned to corn treatment within CrPr and Con treatments, dry corn (**DC**) or high-moisture corn (**HMC**) in the base diet, which resulted in 12 cows per treatment combination. Treatment combinations (CrPr/DC, CrPr/HMC, Con/DC, and Con/HMC) were fed from parturition until 28 ± 3 d PP (treatment period). All cows were fed a common diet to evaluate possible carryover effects of the treatment diets from 29 to 84 ± 3 d PP (carryover period). Cows were offered a prepartum diet beginning 28 ± 3 d before expected parturition date. Cows switched diets on the same day each week, except that the corn treatment diets began on the day of parturition or the next feeding, depending on time of day of parturition. Treatment diets were mixed daily in a tumble mixer and common diets (prepartum and carryover) were mixed daily in a mixer wagon. All diets were formulated to meet or exceed predicted requirements for protein, minerals, and vitamins according to NRC (2001), and water was available at all times in each stall. To adjust for concentrations of individual ingredients in the different TMR, forages were sampled weekly and composited and analyzed every 2 wk, whereas concentrates were sampled weekly and composited and analyzed every month. Dry matter of fermented feeds was determined twice per week by a Koster moisture tester (Koster Moisture Tester Inc., Brunswick, OH) and diets were adjusted accordingly. Ingredient and nutrient composition of the 4 diets fed throughout the experiment are listed in Table 1.

Data and Sample Collection

All samples and body measurements were collected or recorded on the same day of the week during the entire experiment so all collection days are ± 3 d relative to the first day on the treatment rations. Feed offered and refused were recorded for each cow daily throughout the entire experiment. Samples of all diet ingredients (0.5 kg) and orts from each cow (~12.5%) were collected weekly during the entire experiment and stored in plastic bags at −20°C until processed. Milk yield was recorded at each milking from parturition until 84 d PP. Milk samples were collected weekly at each milking, from calving until 28 d PP, and then every other week until 84 d PP. Milk samples were stored with preservative (bronopol tablet; D&F Control Systems, San Ramon, CA) at 4°C for component analysis (Universal Lab Services, East Lansing, MI). Body condition score was recorded 35 d before expected date of parturition to block cows. Body weight and BCS were recorded every other week from 28 d prepartum to 28 d PP, and every 4 wk during the carryover period. Body condition was scored on a 5-point scale by 3 trained investigators (Wildman et al., 1982).

Sample Analysis

Milk samples were analyzed for fat, true protein, lactose, MUN, and SCC by infrared spectroscopy (AOAC