J. Dairy Sci. 97:3815–3821
http://dx.doi.org/10.3168/jds.2013-7767

Effects of supplemental chromium propionate and rumen-protected amino acids on productivity, diet digestibility, and energy balance of peak-lactation dairy cattle

C. F. Vargas-Rodriguez,* K. Yuan,* E. C. Titgemeyer,* L. K. Mamedova,* K. E. Griswold,† and B. J. Bradford*[1]
*Department of Animal Sciences and Industry, Kansas State University, Manhattan 66506
†Kemin Industries, Des Moines, IA 50317

ABSTRACT

Chromium (Cr) feeding in early lactation increased milk production in some studies, but responses to dietary Cr during peak lactation have not been evaluated. Furthermore, interactions of essential amino acids (AA) and Cr have not been explored. Our objective was to evaluate responses to CrPr (KemTRACE chromium propionate 0.04%, Kemin Industries Inc., Des Moines, IA) and rumen-protected Lys (LysiPEARL, Kemin Industries Inc.) and Met (MetiPEARL, Kemin Industries Inc.) and their interaction in peak-lactation cows. Forty-eight individually fed Holstein cows (21 primiparous, 27 multiparous, 38 ± 15 d in milk) were stratified by calving date in 12 blocks and randomly assigned to 1 of 4 treatments within block. Treatments were control, CrPr (8 mg/d of Cr), RPLM (10 g/d of Lys and 5 g/d of Met, intestinally available), or CrPr plus RPLM. Treatments were premixed with ground corn and top-dressed at 200 g/d for 35 d. Diets consisted of corn silage, alfalfa hay, and concentrates, providing approximately 17% crude protein, 31% neutral detergent fiber, and 40% nonfiber carbohydrates. Dry matter intake (DMI) significantly increased with the inclusion of CrPr (22.2 vs. 20.8 ± 0.67 kg/d), and energy-corrected milk (ECM) yield tended to increase. In addition, CrPr increased milk protein yield and tended to increase DMI in primiparous cows but not in multiparous cows. A CrPr × week interaction was detected for milk lactose content, which was increased by CrPr during wk 1 only (4.99 vs. 4.88 ± 0.036%). As a proportion of plasma AA, lysine increased and methionine tended to increase in response to RPLM, but the inclusion of RPLM decreased N efficiency (milk protein N:N intake). Digestible energy intake, gross energy digestibility, and energy balance were not affected by treatments. We observed no treatment effects on feed efficiency or changes in body weight or body condition score. In summary, feeding CrPr increased DMI and tended to increase ECM in cows fed for 5 wk near peak lactation, with primiparous cows showing greater responses in DMI and milk protein yield than multiparous cows.

Key words: lysine, methionine, chromium, essential amino acid

INTRODUCTION

After parturition, cows must adapt to milk secretion, but their daily DMI rarely matches the nutrient demands for that activity (Dalbach et al., 2011). Because of these extremely high nutrient requirements, cows near peak lactation are most likely to experience AA deficiencies, which can limit peak milk and, in turn, decrease whole-lactation productivity.

Chromium (Cr) is involved in many metabolic functions (Mertz, 1993; Bryan et al., 2004); it activates certain enzymes and stabilizes AA and nucleic acids (NRC, 1997; Khalili et al., 2012). Some studies utilized supplemental Cr in diets for lactating cattle and reported increases in milk production (Hayirli et al., 2001; McNamara and Valdez, 2005), whereas others detected enhanced immune responsiveness and disease resistance, particularly in animals under stress conditions (Spears et al., 2012).

It is also known that Cr can potentiate the action of insulin by binding to intracellular insulin receptor sites and promoting signal transduction (Kegley et al., 2000), thereby enhancing carbohydrate metabolism. In addition, Cr can alter protein synthesis (Gentry et al., 1999); although the mechanisms underlying this effect are not completely understood, the effect of Cr on insulin sensitivity has been clearly demonstrated in cattle (Sumner et al., 2007), and insulin signaling promotes protein synthesis. However, there is currently no information about interactions between AA nutrition and Cr supplementation in dairy cattle. Therefore, a critical need exists to further explore responses to Cr in the presence and absence of supplemental AA near peak lactation.

Received November 25, 2013.
Accepted February 15, 2014.
[1]Corresponding author: bbradfor@ksu.edu

MATERIALS AND METHODS

The Kansas State University Institutional Animal Care and Use Committee approved all experimental procedures.

Design and Treatments

Forty-eight lactating Holstein cows (21 primiparous and 27 multiparous, 38 ± 15 DIM) were used in a randomized complete block design with 4 treatments. The cows were stratified by calving date in 12 blocks, and assigned randomly to treatments within block.

All cows were housed in tie-stalls and individually fed a common diet (Table 1). Analysis by the Cornell Net Carbohydrate and Protein System version 6.1 (NDS version 3, Ruminant Management & Nutrition, Reggio Emilia, Italy) estimated metabolizable Lys supply at 148 g/d (6.38% of MP) and metabolizable Met supply at 47 g/d (2.03% of MP) with 22 kg/d DMI in the control diet. Treatments were premixed with ground corn and offered as a top-dress at a rate of 200 g/cow daily for 35 d. Treatments were control, Cr propionate (**CrPr**; 8 mg/d Cr in the form of 20 g/d KemTRACE chromium propionate 0.04%, Kemin Industries Inc., Des Moines, IA), rumen-protected lysine and methionine (**RPLM**; 10 g/d lysine and 5 g/d methionine, intestinally available), or both (CrPr+RPLM). The RPLM supplement was composed of 48.8 g/d of LysiPEARL and 15.3 g/d of MetiPEARL (Kemin Industries Inc.), and was predicted to provide Lys and Met supplies of 6.77 and 2.23% of MP, respectively. Cows were milked 3 times daily (0300, 1100, and 1900 h) and fed once daily (1600 h) for ad libitum intake, targeting 10% daily refusals.

Sample and Data Collection

Feed offered and feed refused were measured for each cow daily to determine DMI. Milk yield was recorded for each cow daily. Body weights and BCS (Wildman et al., 1982) were measured on d 1 and 35. Milk samples were collected 3 d per week for milk composition analysis. Samples of feed ingredients were collected weekly and frozen for analysis. On d 19 to 21 and d 33 to 35, samples of TMR and feed refusals were collected daily and fecal samples were collected at 9-h intervals, representing every 3 h of a 24-h period.

On d 21 and 35 (1430 h), approximately 7 mL of blood was collected from the coccygeal vessels into evacuated tubes containing K3-EDTA (Vacutainer, Becton Dickinson, Franklin Lakes, NJ). Samples were centrifuged at 2,000 × g for 15 min immediately after sample collection, and plasma was harvested and frozen at −20°C until analysis.

Sample Analysis

Samples of diet ingredients, TMR, and feed refusals were dried in a 55°C forced air oven for 48 h, composited by collection period (d 21 vs. 35), ground through a 1-mm screen (Wiley mill, Arthur H. Thomas, Swedesboro, NJ), and analyzed for DM, OM, CP, NDF, and ether extract (**EE**). The DM content was determined by drying at 105°C in a forced-air oven for 16 h. Ash concentration was determined after 4 h of oxidation at 500°C in a muffle furnace. Nitrogen content was determined by oxidation and detection of N_2 (Leco Analyzer, Leco Corp., St. Joseph, MI). Concentration of NDF was determined using an Ankom Fiber Analyzer (An-

Table 1. Ingredient and nutritional composition of the basal diet

Item	Value
Ingredient, % of DM	
Corn silage	31.5
Alfalfa hay	23.4
Wet corn gluten feed[1]	6.8
Ground corn	23.1
Whole cottonseed	4.6
Mechanically extracted soybean meal[2]	2.1
Solvent-extracted soybean meal	5.1
Ca salts of long-chain fatty acids[3]	0.8
Micronutrient premix[4]	2.6
Nutrient, % of DM unless otherwise noted	
DM, % as-fed	57.9
OM	91.3
CP	16.7
NDF	31.7
ADF	20.1
fNDF[5]	22.1
NFC	39.8
Ether extract	3.1
Gross energy, Mcal/kg	4.11
Digestible energy,[6] Mcal/kg	3.34
ME,[7] Mcal/kg	2.92
NE_L,[8] Mcal/kg	1.87
Model-predicted ME,[9] Mcal/kg	2.50

[1]SweetBran (Cargill Inc., Blair, NE).

[2]Soy Best (Grain States Soya, West Point, NE).

[3]Megalac-R (Church & Dwight Co., Princeton, NJ).

[4]Premix consisted of 45.1% limestone, 32.2% sodium bicarbonate, 6.4% magnesium oxide, 5.2% sodium chloride, 5.2% vitamin E premix (44 IU/g), 0.45% vitamin A premix (30 kIU/g), 0.19% vitamin D premix (30 kIU/g), 2.1% 4-Plex (Zinpro Corp., Eden Prairie, MN; contains 2.58% Zn, 1.48% Mn, 0.90% Cu, 0.18% Co, 8.21% Met, and 3.80% Lys), 0.96% selenium premix (600 mg/kg Se), 0.45% Zinpro 100 (Zinpro Corp.; contains 10% Zn and 20% Met), 0.03% ethylenediamine dihydriodide premix (3.65% I), 0.88% Kallsil (Kemin Industries Inc., Des Moines, IA), and 0.88% Myco CURB (Kemin Industries Inc.).

[5]Forage NDF.

[6]Digesible energy (DE) = (gross energy (GE) intake – GE in feces)/DMI.

[7]ME = [1.01 × (DE, Mcal/kg) − 0.45] + 0.0046 × (ether extract, %, − 3).

[8]NE_L = 0.703 × ME (Mcal/kg) – 0.19 + [(0.097 × ME, Mcal/kg, + 0.19)/97] × [ether extract, %, − 3].

[9]ME predicted by CNCPS 6.1 (NDS version 3, Ruminant Management & Nutrition, Reggio Emilia, Italy).