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Effect of Chromium Propionate Supplementation on Lactation Performance and Blood Parameters of Dairy Cows

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Abstract: The objective of this study was to determine the effect of chromium propionate (Cr, 0.4%) supplementation on lactation performance and blood parameters of dairy cows. One hundred primiparous Holstein cows were grouped based on parity and randomly assigned to five supplemental doses (I, II, III, IV, V) of 0, 25, 50, 100 and 150 mg of Cr propionate/kg of concentrate. Experimental diets were fed from approximately 30 days prepartum until 60 days postpartum. Lactation performance: Cr Prop addition did not affected fat, protein, lactose in milk but supplementation of 50 mg of Cr propionate/kg of concentrate did decrease SCC and increase DMI and milk yield. Blood indicators: Addition of Cr can increase serum glucose except the treatment of 150 mg, increase the content of Cr in serum and decrease β-hydroxyl butyrate and NEFA.

Key words: Dairy cows, chromium propionate, lactation performance, blood parameters, fate, protein

INTRODUCTION

The beneficial role of Cr in human nutrition has been well documented (Mertz, 1993).Chromium is required for normal metabolism of carbohydrate, proteins and lipids. Dietary supplementation of Cr could be beneficial for the health and well being of ruminants.

The period of late gestation and early lactation is one of metabolic stress for dairy cows. Stressors can induce Cr deficiency due to increased glucose metabolism, mobilization of Cr from body stores and irreversible loss of Cr in urine (Anderson *et al*., 1991). Cr had received attention in animal nutrition (Chang *et al*., 1992; Mowat *et al*., 1993; Moonsie-Shageer and Mowat, 1993). Dairy cows are also under great physical, psychosocial and metabolic stesses during late pregnancy and early lactation.

The role of Cr in metabolism is believed to be through glucose tolerance factor (Schwarz and Mertz, 1959). Glucose tolerance factor has been shown to be ineffective if insufficient Cr (Toepfer *et al*., 1977).

Many studies of Cr supplementation performed in dairy cattle but the main conclusions were inconsistency among results reported. Yang *et al*. (1996) reported milk production in primiparous but not in multiparous cows has increased when supplemented Cr. Supplemental Cr picolinate has no positive effect on feed intake or milk yield during the 1st 8 weeks of lactation (Jackson *et al*., 1993). However, supplemental Cr methionine has increased DMI and milk yield in early lactation (Smith *et al*., 2005; Deng *et al*., 2009) deduced Cr of high concentration can affected the absorbability of Zn^{2+} and Mn^{2+}. Therefore, the hypothesis of this experiment was to investigate the effects of different doses Cr supplementation on early lactation performance of Holstein cows.

MATERIALS AND METHODS

Experimental design and cow management: One hundred primiparous Holstein cows (250 days of pregnant) were randomly assigned by parity to treatment. Treatments consisted of the following diets: control (no supplemental Cr) and 25, 50, 100, 125 mg of Cr propionate/kg of concentrate (KemTrace Chromium Propionate, Kemin Industries China Zhuhai Inc.).

Cows were housed in a covered free-stall barn. The trial commenced on October 20, 2010 and ended on January 30, 2011. Prior to initiation of the study, cows adapted to the experimental conditions for 10 days. Experimental diets were fed as a TMR (Table 1) from approximately 30 days prepartum until 60 days postpartum.

Milk sampling and processing: On day 0, 23, 43, 65 and 87 of the experiment, dry matter intake of every cow was measured. Milk samples were obtained on day 45, 60 and 90 to test milk fat, milk protein, lactose, SCC. Milk composition in fresh milk of all cows was determined with near infrared milk ingredients analyzer (MIRIS DMA, Sweden). Milk yield was recorded weekly for 3 consecutive days.

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Table 1: Dietary ingredients and composition of feeds fed to dairy cattle in late pregnancy and early lactation

Ingredients (DM %)	Dry	Lactation
Ration composition		
Alfalfa hay (US)	0.00	18.20
Alfalfa hay (China)	0.00	5.20
Chinese wildrye hay	34.70	
Maize silage	33.30	26.60
Concentrate	32.00	50.00
Concentrate composition		
Corn	42.40	31.50
Soy	6.40	8.20
Cottonseed meal	21.30	10.20
Rapeseed meal	0.00	10.40
DDGS	21.50	10.80
Beet meal	0.00	10.40
XP	0.90	1.10
Fatty acid calcium	0.00	2.70
Esterified glucomannan	0.00	0.10
Molasses	0.00	8.80
Vitamins-minerals mix	7.20	5.80
Chemical composition[1]		
DM (%)	51.00	53.00
CP (%)	14.30	19.00
ADF (%)	35.20	20.90
NDF (%)	49.40	32.60
NE_L (Mcal kg^{-1}) of DM	1.34	1.61
Ca (%)	1.10	1.10
P (%)	0.34	0.39

[1]All data are analyzed except for NE_L which were calculated from NRC (2001)

Blood sampling and analysis: Blood samples were taken from six cows from every treatment. Blood was collected on day 25, 35, 45, 65 and 90 via coccygeal vein. Blood was placed on ice immediately post-collection and centrifuged at 3000 g for 15 min. The serum was preserved at −20°C until analysed for metabolites.

The concentration of blood sugar, β-hydroxyl butyrate and NEFA were measured using commercial kits. Graphite furnace atomic absorption spectrometry (ThermoM6) were used in determination of serum Cr with wavelength 357.9 nm, spectral passband 0.5 nm and pure argon gas as protection. Drying temperature/time = 100°C/25 sec, ash temperature/time = 200°C/10 sec, atomization temperature/time = 2400°C/2 sec, Clear temperature/time = 2600°C/3 sec, injection volume = 10 μL.

Statistical analysis: Data were analyzed statistically as a randomized block design using the one way ANOVA.

RESULTS AND DISCUSSION

Dry matter intake and milk production variables: Treating cows with CrP tended to increase DMI over the entire period (Fig. 1). Chromium propionate increased feed intake both before calving and after.

Dry-matter intake was relatively stable during the prepartum period and gradually increased following parturition to a maximum around day 57 of lactation

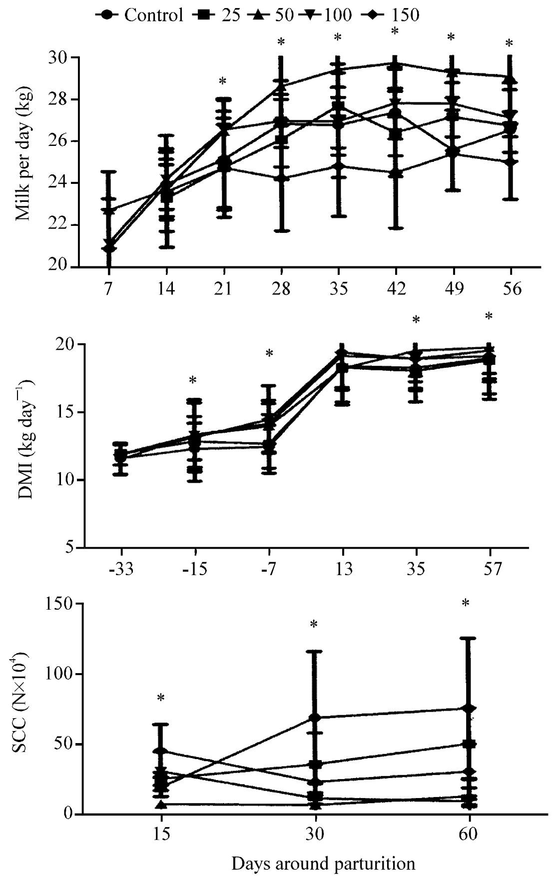

Fig. 1: Milk per day, dry matter intake and SCC in milk of Holstein cattle in late pregnancy and early lactation fed different levels of chromium propionate

(Fig. 1). Overall, DM intake of control was significant lower than Cr-treated cows during the 1st 8 weeks of lactation.

In the beginning of lactation, milk yield was similar between control and treated cows but it showed significant difference around day 21. Content of milk lactose, protein and fat did not vary with treatment. Although, supplemental Cr did not affect milk composition, increased DMI in treatment (Yu *et al*., 2006). Popovic *et al*. (2000) observed a higher average daily milk yield and higher values for milk fat, protein and lactose. Supplemental Cr in early lactation can controlled SCC effectively (Fig. 1 and Table 2). These periods coincide with impaired lymphocyte and neutrophil function and increased incidence of mastitis (Kehrli *et al*., 1989). Burton *et al*. (1993) reported that supplemental Cr can alter specific immune responses of stressed cattle.

The effect of glucose lack on adipose tissue lipolysis has detrimental effects on feed intake and can lead to fat

Table 2: The effect of chromium propionate on DMI, milk composition of cows

Items	Treatment[1] C	I	II	III	IV	SEM	p-value
DMI (kg day^{-1})	15.42^a	15.53^a	16.36^b	16.52^b	16.43^b	2.61	0.048
Milk yield (kg day^{-1})	25.39^a	25.05^a	27.36^b	26.06^{ab}	23.84^a	2.30	0.038
Fat (%)	3.56	3.68	3.61	3.62	3.59	0.15	0.091
Protein (%)	3.32	3.23	3.21	3.25	3.26	0.10	0.166
Lactose (%)	4.41	4.44	4.46	4.38	4.37	0.18	0.109
SCC (N×10^4)	54.86^a	37.52^a	9.63^b	11.15^a	33.42^a	11.58	0.047

$^{a, b}$Means within a row with different superscripts differ ($p \leq 0.05$); [1]C = No supplemental Cr, I = 25 mg of Cr propionate/kg of concentrate, II = 50 mg of Cr propionate/kg of concentrate, III = 100 mg of Cr propionate/kg of concentrate, IV = 150 mg of Cr propionate/kg of concentrate

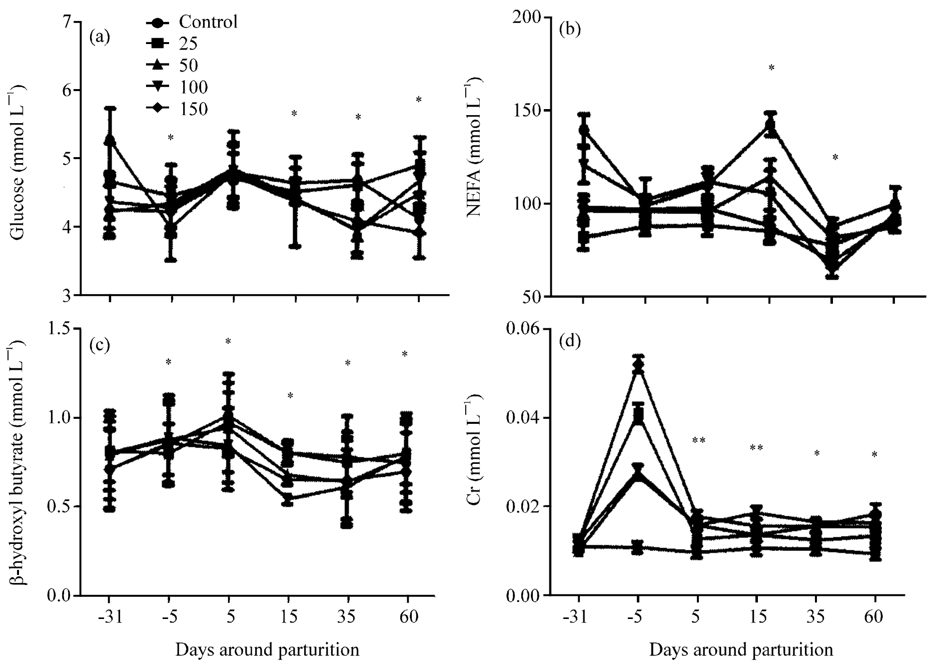

Fig. 2: a) Serum concentration of glucose (mmol L^{-1}); b) non-esterified fatty acid (mmol L^{-1}); c) β-hydroxyl butyrate (mmol L^{-1}) and d) Cr (mmol L^{-1}) in Holstein cattle in late pregnancy and early lactation fed different levels of chromium propionate

accumulation in the liver, perhaps further diminishing gluconeogenic capacity (Drackley, 1999; Overton and Waldron, 2004).

Adaptive mechanisms may eventually lead to increased conservation of body Cr stores or redistribution of Cr in specific tissues in primiparous cows (Yang *et al*., 1996) as shown with trained athletes (Anderson, 1994). Moreover, milk yields increased and then decreased with increasing Cr Prop supplementation. These observations suggest that there might have been Cr toxicity at the highest dose although, the toxic level of Cr for ruminants is unknown.

Propionic acid as a kind of gluconeogenic precursor can enhance gluconeogenesis. Glucose which is the unique source of lactose can improve milk production. Furthermore, Cr is an essential trace element for glucose transport into insulin-sensitive cells through its interaction. Most studies have shown improved glucose tolerance (Hayirli *et al*., 2001; McNamara and Valdez, 2005). Sano *et al*. (1996) showed that supplemental organic Cr in stressed rams fed a high-moisture corn diet tended to have increased conversion of propionate to glucose as well as increased propionate turnover rates. Increased glucogenic capacity and possibly increased propionate absorption were suggested with supplemental Cr. Overall chromium propionate can increase lipogenesis and decrease net lipolysis in adipose tissue and increase feed intake and milk yield.

Blood indicators: Cr concentrations (Fig. 2) also sharply increased and then gradually decreased following intravenous glucose infusion in both prepartum and postpartum. Subiyatno *et al*. (1996) reported an improvement in glucose tolerance in primiparous cows

Table 3: The effect of chromium propionate on glucose, NEFA, BHBA and Cr concentration in serum

	Treatment[1]						
Items (mmol L^{-1})	C	I	II	III	IV	SEM	p-value
Glucose	4.080[a]	4.690[b]	4.250[ab]	4.300[ab]	3.750[b]	0.4200	0.042
NEFA	91.000[a]	88.000[ab]	74.000[b]	63.000[b]	68.000[b]	7.2900	0.041
BHBA	0.820[a]	0.750[ab]	0.750[ab]	0.720[b]	0.720[b]	0.0800	0.033
Cr	0.011[a]	0.015[ab]	0.014[ab]	0.015[ab]	0.017[b]	0.0016	0.008

[a, b]Means within a row with different superscripts differ (p = 0.05); [1]C = No supplemental Cr, I = 25 mg of Cr propionate/kg of concentrate, II = 50 mg of Cr propionate/kg of concentrate, III = 100 mg of Cr propionate/kg of concentrate, IV = 150 mg of Cr propionate/kg of concentrate

but not in multiparous cows when they were fed a diet supplemented with 0.5 mg Cr/kg of DM during the periparturient period.

Chromium in the +3 state is a trace mineral recognized as required for optimal insulin action and uptake of glucose in insulin-sensitive organs (Anderson *et al*., 1987).

Postpartum data shown in Fig. 2 were averages of measurements obtained on day 1 and 21 relative to actual calving date. Concentrations of serum glucose increased significantly by treatments except the treatment of 150 mg Cr. BHBA and NEFA were lower than untreatment (Table 3).

CONCLUSION

This study indicates that supplementing dairy cows with Cr Prop >90 days increased DMI, milk production and decreased SCC, NEFA, BHBA when supplementation of 50 mg of Cr propionate/kg of concentrate.

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