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Effects of Supplemental Chromium on Lactation and Some Blood Parameters of Dairy Cows in Late Gestation and Early Lactation

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ABSTRACT

This study was carried out to evaluate the effects of chromium supplementation as chromium-L-methionine (Cr-Met) on lactation performance and some blood components of Holstein dairy cows in late gestation and early lactation. Sixty multiparous Holstein dairy cows according to prior lactation, parity, body weight and expected calving date were divided equally (30 cows/treatment) and were randomly allocated to one of the two groups. Group 1 received no Cr supplement and served as the control. Group 2, received supplemental Cr at manufacturer's recommended level (8 mg/head per day) from 21 days before expected calving date until 21 days of lactation. Milk productions of animals were recorded every 15 days until 60 days in milk (DIM). Blood samples were collected at -7, 0 and 21 days relative to actual calving time for determination of serum protein fraction, maternal serum IgG concentration, serum Ca and P and urea nitrogen. Adding chromium to the diet of dairy cows increased milk yield in the first month of lactation. Percentage of lactose and lactose yield increased significantly through the experiment in the supplemented group. In the first month of lactation, milk protein yield increased significantly while a tendency was observed for fat yield in the supplemented group. Cr supplementation increased albumin and albumin to globulin ratio in 21 days postpartum. Maternal serum IgG concentration tended to increase at parturition. Supplemental Cr had no effect on serum Ca, P and urea concentration in periparturient period. The results suggest that Cr supplementation improves milk yield and some blood parameters of dairy cows in late gestation and early lactation.

Key words: Chromium, late gestation, IgG concentration, albumin, globulin

INTRODUCTION

The periparturient period is an extremely important time for dairy cows and the offspring they are carrying. During the 3 to 4 week before parturition, cows are not only challenged by exposure to diseases but also they must transfer IgG from serum into colostrum to provide immunity for their calves (Franklin *et al.*, 2005). Unfortunately, the immune system of dairy cows becomes depressed during the periparturient period (Kehrli *et al.*, 1989a, b), causing them to be less able to respond to challenges (Cai *et al.*, 1994). In addition, sufficient passive transfer of immunity to the calf may be jeopardized if cows are not able to transfer enough IgG into colostrum to provide adequate colostrum quality (Rea *et al.*, 1996).

Chromium is generally accepted as an essential nutrient that potentiates insulin action and thus influences carbohydrate, lipid and protein metabolism (NRC, 2001). Chromium supplementation of late-gestation and early-lactation dairy cattle may be particularly beneficial. In rats, the fetus accumulates Cr, especially in the last trimester, depleting Cr stores (Anderson, 1987). Also, stress, such as the stress of late gestation and early lactation, increases urinary excretion of Cr in rats (Anderson *et al*., 1988), further depleting Cr stores.

Previous research evaluating metabolic responses of Cr in late gestation or early lactation dairy cattle has shown variable responses. In some studies increase in milk yield have been observed as a result of Cr supplementation (Sadri *et al*., 2009; Hayirli *et al*., 2001; Smith *et al*., 2005). However, Subiyatno *et al*. (1996) and Pechova *et al*. (2002) have not observed this response.

Chromium supplementation may mediate immune suppression often observed in stressed animals. During stress (e.g., early lactation), the immune system is challenged and the need to synthesize essential proteins such as albumin and globulins increases (West, 1999; NRC, 2001). Thus, the Cr may have contributed to sustaining adequate nutrient supply and boosting immunity while maintaining milk production peak (Al-Saiady *et al*., 2004).

Newly arrived beef cattle supplemented with Cr had improved humoral immunity as indicated by increased vaccination titers (Burton *et al*., 1994) and total immunoglobulin concentrations (Chang and Mowat, 1992; Moonsie-Shageer and Mowat, 1993). In addition there are relatively few papers on the effect of Cr supplementation on the metabolism of other mineral substances. Interactions between Cr, Ca and Mg have been reported by Moonsie-Shageer and Mowat (1993), who found Cr supplementation to be associated with Ca and Mg concentration increases on Day 7 of the trial. Therefore, the objective of this study was to determine the effect of chromium supplementation on lactation performance and some blood parameter of Holstein cows during the late gestation and early lactation.

MATERIALS AND METHODS

This study was conducted in a large commercial dairy farm in Kermanshah province in the west of Iran. Sixty multiparous Holstein cows (second and third parity) in late gestation were randomly assigned into two groups. Animals were placed in an open lot. Cows were allocated into two groups based on their prior milk yield (6972±390), body weight (682±33 kg at the commencement of the study) and anticipated calving date. Cows were assigned to one of the two treatments, 1) a nutritionally adequate diet with no supplemental Cr (control) or 2) control diet supplemented with 8 g per head per day Cr-L-Met (Micro-Plex, Zinpro, Eden Prairie, MN, USA) providing 8 mg Cr/head/d from 3 week before anticipated calving date through 3 week after parturition. Because Cr requirements of dairy cows are not known (NRC, 2001), the quantity of Cr added at manufacturer's recommended level. Cows were fed a TMR at ad libitum to meet the predicted requirements for energy, protein, minerals and vitamins according to NRC (2001), once daily prepartum and twice daily postpartum. Clean water was available at all times. In precalving, Cr was top dressed with 100 g of ground barley and in postcalving cows received Cr via an individual oral drench once a day after morning milking.

Daily milk productions of animals were recorded at 15, 30, 45 and 60 DIM. Milk samples were collected at the same day from three consecutive milking and freezed at -20°C until analysis. Milk samples were analysed for fat, CP and lactose. Milk fat, CP and lactose were determined using an automated near infrared spectroscopy analyser (Milko Scan, 134 BN, Foss Electric, Hillerod, Denmark).

Blood samples were collected at days -7, 0 and 21 relative to actual calving time via the coccygeal vein for determination of serum protein fraction, serum calcium (Ca), inorganic phosphorus (P) and urea concentration. Blood samples also were collected from cows at calving for determination of serum IgG concentration. Blood was centrifuged for 15 min at 3500 rpm. The serum was preserved at -20°C until analysed for metabolites. The amounts of total serum protein, albumin, urea, calcium (Ca) and inorganic phosphorus (P), were measured by commercial kits (Pars Azmoon, Tehran, Iran) using an autoanalyser (Biotecnica, Targa 3000, Rome, Italy). The concentration of globulin calculated as the difference between total serum protein and albumin. Radial immunodiffusion techniques (IgG SRID Kit; Veterinary Medical Research and Development, Pullman, Washington, USA) were performed to quantify serum IgG concentration.

Experimental design was completely randomized design with 30 cows in each group. Analysis was carried out using t-test. The differences between treatments were considered significant if $p<0.05$, whereas when $0.05<p\leq 0.10$, differences were considered to indicate a trend towards significance. The statistical analysis were performed using SAS (2003).

RESULTS

Effects of Cr supplementation on milk yield and milk composition are summarized in Table 1. During the first month of lactation, Cr supplementation increased yield of milk ($p<0.05$) and 4% FCM ($p = 0.05$) but the milk yield was not different between groups in the second month of lactation ($p>0.05$). Percentage of lactose and lactose yield increased significantly in first ($p<0.01$) and second month ($p<0.05$) of lactation in cows receiving Cr. In addition milk protein yield ($p<0.05$) and percentage of fat ($p = 0.07$) increased in supplemented group during the first month of lactation.

The effects of supplemental dietary Cr on serum IgG level at the day of calving and serum protein fraction at -7, 0 and 21 days of the experiment are given in Table 2. Serum IgG level in cows fed Cr supplementation was higher ($p = 0.07$) than cows fed control diet. Concentrations of serum protein were not affected by treatment in prepartum

Table 1: Effect of Cr supplementation on mean milk yield, milk components and composition

Items	Control	Treatment	p-value
1st month			
Milk (kg)	34.08^{b}	37.13^{a}	0.04
FCM 4% (kg)	30.44	33.13	0.05
Fat (%)	3.28	3.28	0.93
Fat (kg)	1.12	1.21	0.07
CP (%)	3.02	3.03	0.92
CP (kg)	1.02^{b}	1.12^{a}	0.03
Lactose (%)	4.00^{b}	4.27^{a}	<0.01
Lactose (kg)	1.35^{b}	1.58^{a}	<0.01
2nd month			
Milk (kg)	37.58	40.50	0.10
FCM 4% (kg)	34.82	37.47	0.11
Fat (%)	3.50	3.51	0.92
Fat (kg)	1.31	1.41	0.13
CP (%)	3.45	3.37	0.30
CP (kg)	1.29	1.36	0.29
Lactose (%)	4.07^{b}	4.24^{a}	0.01
Lactose (kg)	1.52^{b}	1.71^{a}	0.01

Means within a row with different superscripts differ significantly at $p<0.05$, FCM: Fat corrected milk, CP: Crude protein

Table 2: Effect of Cr supplementation on some serum protein concentrations in transition period

Items	Control	Treatment	p-value
-7 days			
Total proteins (mg dL^{-1})	68.4	69.3	0.63
Albumin (mg dL^{-1})	36.0	38.3	0.15
Globulin (mg dL^{-1})	32.4	31.0	0.70
Albumin/globulin	1.18	1.28	0.48
At calving			
Maternal serum IgG (mg dL^{-1})	1960	2170	0.07
Total proteins (mg dL^{-1})	65.8	68.1	0.54
Albumin (mg dL^{-1})	34.5	37.0	0.34
Globulin (mg dL^{-1})	31.3	31.1	0.94
Albumin/globulin	1.16	1.24	0.57
+21 days			
Total proteins (mg dL^{-1})	68.0	68.4	0.22
Albumin (mg dL^{-1})	32.80[b]	36.50[a]	0.03
Globulin (mg dL^{-1})	35.2	31.9	0.23
Albumin/globulin	0.96[b]	1.17[a]	0.05

Means within a row with different superscripts differ significantly at $p<0.05$

Table 3: Effect of Cr supplementation on Ca, P and urea concentrations (mg dL^{-1}) of blood in transition period

Items	Control	Treatment	p-value
-7 days			
Ca (mg dL^{-1})	8.11	9.14	0.17
P (mg dL^{-1})	5.81	6.22	0.53
Urea nitrogen (mg dL^{-1})	34.90	36.40	0.54
At calving			
Ca (mg dL^{-1})	7.51	8.18	0.17
P (mg dL^{-1})	5.09	5.67	0.23
Urea nitrogen (mg dL^{-1})	34.80	35.70	0.82
+21 days			
Ca (mg dL^{-1})	7.94	8.88	0.20
P (mg dL^{-1})	5.70	6.09	0.42
Urea nitrogen (mg dL^{-1})	38.50	35.20	0.35

Means within a row with different superscripts differ significantly at $p<0.05$

and the day of calving ($p>0.05$) but serum albumin concentration and albumin/globulin ratio increased significantly ($p<0.05$) in 21 days postpartum.

Table 3 shows the effects of Cr supplementation on serum Ca, P and urea nitrogen (mg dL^{-1}). The concentrations of Ca, P and urea were not different between groups.

DISCUSSION

In the present experiment Cr supplementation increased milk yield and 4% FCM during the first month of lactation but had no effects on milk yield in the second month of lactation. This result is in agreement with some previously reported results (Sadri *et al*., 2009; Besong, 1996; Hayirli *et al*., 2001; Smith *et al*., 2005) but not with others like Subiyatno *et al*. (1996) and Pechova *et al*. (2002). In studies where increases in milk production have been observed, increases in postpartum DMI have also been observed (Hayirli *et al*., 2001; Smith *et al*., 2005; Besong, 1996; McNamara and Valdez, 2005). Hayirli *et al*. (2001) and Besong (1996) reported increased milk yield and subsequently, postpartum DMI when cows were fed supplemental Cr during the periparturient period. It would seem logical that DMI would increase when milk production increases, especially considering body tissue mobilization, as indicated by a reduction in blood NEFA, with Cr supplementation (NRC, 2001). It is not yet clear how supplemental Cr may increase milk yield in early lactation. Recently McNamara and Valdez (2005) suggested that the effect of Cr on increment of glucose flux into adipocytes may reduce net lipolysis, allowing increased feed intake, reducing the use of body reserves in very early lactation and allowing more substrates for the mammary gland with subsequently increased milk yield.

The results of the current study indicated that Cr supplementation in periparturient period increased milk protein yield and percentage of fat during the first month of lactation while lactose and lactose yield increased in both first and second month of lactation.

Our results are similar with those obtained by Hayirli *et al.* (2001) and Nikkhah *et al.* (2010) but in disagreement with the result of Sadri *et al.* (2009), Smith *et al.* (2005) and McNamara and Valdez (2005). Hayirli *et al.* (2001) reported that increasing Cr supplementation caused quadratic increases in milk fat and lactose yields. Similarly, Nikkhah *et al.* (2010) reported milk output of fat, protein and total solids increased by providing Cr at 0.05 mg but not 0.10 mg kg^{-1} $BW^{0.75}$. Although, Smith *et al.* (2005) and McNamara and Valdez (2005) found no effect of Cr supplementation on milk components and composition.

It is well known that chromium is involved in protein metabolism (Sahin *et al.*, 2002). The increase in serum albumin may be due to increased amino acid synthesis in the liver, suggesting that Cr may improve amino acid synthesis, possibly via insulin Moonsie-Shageer and Mowat (1993). Schroeder *et al.* (1965) concluded that Cr plus insulin enhanced incorporation of several amino acids into protein in rats. Albumin is synthesized by the liver and is essential for circulating metabolite transportation (NRC, 2001). During stress (e.g., early lactation), the immune system is challenged and the need to synthesize essential proteins such as albumin and globulins increases (West, 1999; NRC, 2001). As suggested by Nikkhah *et al.* (2010) Cr may improve hepatic amino acid balance and albumin synthesis to maintain the augmented hepatic and mammary nutrient turnover. The results of our study are in agreement with the results of Moonsie-Shageer and Mowat (1993), Nikkhah *et al.* (2010) and Bakhiet and Elbadwi (2007) but disagree with the results of El-Hommosany (2008) and Al-Mashhadani *et al.* (2010). Furthermore, the increased albumin to globulin ratio is in agreement with that reported by Al-Saiady *et al.* (2004).

Serum IgG level in cows fed Cr supplementation tended to increased in treated group. This result is in agreement with most experiments involving supplemental Cr. Total IgG was increased in stressed feeder calves receiving supplemental Cr nicotinate (Kegley and Spears, 1995) and quail chicks received chromium chloride (El-Hommosany, 2008). Total IgG1 and IgM were increased after transport stress in calves supplemented with high-Cr yeast (Chang and Mowat, 1992; Moonsie-Shageer and Mowat, 1993). However, these results contradict with findings of Kegley *et al.* (1997). They reported that total IgG was decreased with supplementation of Cr nicotinate in stressed calves. It is well known that immunoglobulin production is regulated by specific enzymes that have a trace element at their core, the most common being Cu and Zn (Fielden and Rotilio, 1984). Possibly, Cr may be another element that participates in certain enzymes that increase immunoglobulin synthesis or Cr may influence Cu and or Zn metabolism, thus indirectly affecting immunoglobulin production.

The effects of dietary Cr supplementation on Ca, P and urea concentration are presented in Table 3. Supplemental Cr didn't affect plasma level of Ca, P and urea. These finding are similar with the results of Pechova *et al.* (2002) and El-Hommosany (2008) for plasma level of P.

CONCLUSION

Supplementation with Cr-Met during the periparturient period improved milk yield, percentage of lactose and lactose yield. Milk protein yield increased significantly while a tendency was observed for fat yield in the supplemented group in the first month of lactation. Moreover, Cr supplementation increased maternal serum IgG concentration at parturition. The results of this experiment also suggest that supplemental Cr had positive effect on protein metabolism by increasing serum albumin and albumin to globulin ratio.

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