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Full Length Research Paper

Effects of supplemental chromium-methionine on reproductive performance of dairy cows in transition period

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This experiment was conducted to study the effects of supplemental chromium on the reproductive performance of dairy cows. Thus, twenty multiparous Holstein cows (parity 3) were allocated to two treatments groups with ten replicates in a completely randomized design. In this study, the treatment consists of control group which received no chromium supplementation and treatment group which received 5 g/day of chromium from chromium methionine. The cows used for this experiment were within the range of 5 weeks prior to parturition to 12 weeks after parturition. Reproduction parameters consisting of insemination index and numbers of open days, clinical metabolic disorders which included acidosis, milk fever, retained placenta and displaced abomasums, and also clinical puerperal complications consisting of mastitis, endometritis and ovarian cysts, were determined. The results indicated that chromium (Cr) supplementation significantly caused a decrease in the numbers of open days ($p < 0.05$). Clinical metabolic disorders and clinical puerperal complications were not affected by chromium methionine supplementation. The results of this experiment also showed that chromium methionine supplementation in multiparous dairy cows diet may improve their milk yield and reproductive performance in transition period.

Key words: Dairy cow, transition period, chromium methionine, reproduction.

INTRODUCTION

The relevance of the trace element chromium (Cr) to human and animal nutrition has been known for more than 40 years. Cr is present in the environment mostly in its trivalent form (Cr^{+3}) which is more stable than the hexavalent form (Cr^{+6}). Cr^{+3} are known for its *in vivo* antioxidative activity and favorable effects on the stability of proteins and nucleic acids (Anderson, 1994). However, its most important metabolic effect consists of an enhancement of insulin activity by its presence in an organometallic molecule known as the glucose tolerance factor (GTF). The detailed structure of GTF is unknown, but it is assumed that the factor consists of Cr^{+3}, nicotinic and glutamic acids, glycine, and cysteine (Ducros, 1992). Cr is biologically active as part of an oligopeptide, chromodulin, potentiating the effect of insulin by facilitating insulin binding to receptors at the cell surface. With Cr acting as a cofactor of insulin, the activity of Cr in the organism is parallel to insulin functions (Pechova and Pavlata, 2007). Cr supplementation in late-gestation and early-lactation dairy cattle may be particularly beneficial. Stress such as the stress of late gestation and early lactation increases urinary excretion of Cr in rats (Anderson, 1994), further depleting Cr stores.

Most of the Cr present in animal tissues is bound in the GTF. Data on the distribution of Cr in animal tissues is rather sporadic. Low concentrations with age decline (Mertz, 1997) can be found in almost all tissues. In man, the concentration is highest in lung tissue and decreases in the following order: liver, pancreas, striated muscles of the heart, kidney, spleen and brain (Lentner, 1981). Blood concentration of Cr is not parallel to that stored in the tissue (Underwood, 1977), but reflects exposure to Cr

(Barceloux, 1999). Cr enhances the binding of insulin to cell membrane receptors and the optimization of insulin activity results for better regulation of glucose uptake by cells, improved control of blood glucose concentration, and maximization of the energetic potential. Consequences of Cr deficiency, which are probably associated with disturbed interaction between Cr and insulin, include lowering of glucose tolerance, increased insulin concentration, glycosuria, growth impairment, shortening of productive age, increased concentration of cholesterol and triacylglycerols, infertility, and peripheral neuropathies (Anderson, 1994). Manifestations of Cr deficiency usually develop in animals affected by metabolic stress or that are exposed to physical strain. Available data on Cr concentration in rations of farm animals is insufficient. Moreover, even rations containing Cr concentrations which satisfy the need during a normal production period can become deficient in critical situations, such as advanced pregnancy, parturition, onset of lactation, weaning, transport, etc. The aim of this work was to assess the effects of dietary supplementation of Cr from Cr-Met, on the reproductive performance of 5 weeks preparturient through 12 weeks postpartum dairy cows.

MATERIALS AND METHODS

Animal and treatments

Twenty multiparous Holsteins (parity 3) housed in free stalls at the Esfahankesht farm of Esfahan city, Iran, were randomly allocated to two treatment groups: ten cows were supplemented once daily with 5 g/day of Cr from Cr-Met via corn dough ball after the morning milking, while the other 10 cows received no Cr supplementation. Cows received treatments 5 weeks prepartum through 12 weeks postpartum once daily. From 5 to 12 weeks a total mixed diet (NRC, 2001) was offered to all cows (ad libitum intake). Random samples were taken from the total mixed rations (TMR) diets which were sent to a laboratory for analysis. Also, the amount of Cr in water and diets were determined by atomic absorption system (Table 1).

Reproduction data

Reproduction parameters (insemination index and number of open days) were calculated. Clinical metabolic disorders (acidosis, ketosis milk fever, placental retention and displaced abomasum) and clinical puerperal complications (mastitis, ovarian cyst and endometritis) were recognized by veterinarians.

Statistical analyses

Number of open days was analyzed by using General Linear Model Procedures of SPSS 16 in the computer for a completely randomized design with two treatments and ten replicates. Duncan multiple range test was used to test significant differences in treatments. Insemination index and clinical puerperal complications (mastitis, ovarian cyst and endometritis) were analyzed by the Kolmogorov-Smirnov test statistic (Petrie and Watson, 1999).

$$Yijk = \mu + Aj + Bk + ABjk + Eijk$$

Where Yijk is the dependent variable; μ is the overall mean; Aj is the treatment effect; Bk is the period effect; A × Bjk is the interaction effect of treatment and period; and Eijk is the residual error.

RESULTS AND DISSCUSION

Reproduction parameters

The trial feeding of Cr methionine in the transition period led to a significant decrease in serum cortisol concentration ($p < 0.05$) (Khalili et al., 2011). The decrease in serum cortisol concentration may lead to increase in insulin effects on reproductive performance. The Cr supplementation significantly caused a decrease in the numbers of open days ($p < 0.05$) (Table 2). Decrease in open days was also observed in other studies, as resulting from the fact that the decreased tissue mobilization decreased weight loss at the beginning of milking. Cr supplementation reduced the non-esterified fatty acid (NEFA) of the plasma and this could be because of an increase of insulin sensitivity or because of an increase of dry matter intake which has been reported as a response to the administration of organic Cr (Besong et al., 1996; Bryan et al., 2004; Stahlhut, 2004; Yang et al., 1996). Only a limited number of researches indicate that Cr supplementation may improve reproduction in cattle. Cr supplementation reduced the number of open cows in one of two experiments with primiparous dairy cows but not in multiparous cows (Yang et al., 1996). Pregnancy rate tended to be higher in intensively grazed dairy cows supplemented with Cr than in controls (Bryan et al., 2004). Cr also affected reproduction in beef cows grazing in pastures. Providing Cr in a free choice mineral improved pregnancy rate in beef cows (Stahlhut et al., 2006a). The improvement in reproduction was due to increased pregnancy rate in cows between 5 years of age or younger. Cr did not affect pregnancy rate in beef cows between 6 years of age or older.

The improved pregnancy rate was associated with much lower plasma NEFA concentrations at approximately 21 and 79 days postpartum in Cr supplemented cows (Stahlhut et al., 2006a). Chromium supplementation reduced postpartum body weight loss in 2 and 3 years old cows but not in older cows (Stahlhut et al., 2006a). Supplementation of Cr in a free choice mineral reduced the interval from calving to first estrus and tended to improve pregnancy rate in primiparous Zebu beef cows in Brazil (Aragon et al., 2001). Body weight gain was also greater in Cr supplemented cows from parturition

Table 1. Dry matter composition of basal diets fed to non-lactating or lactating cows.

Diet content	Dry off (%)	Close up (%)	Lactating (%)
Corn silage	50	48	44.6
Alfalfa hay	19.3	22.8	14.5
Wheat straw	15	13.5	-
Concentrate	15.7	16.7	28.9
Concentrate composition (%)			
Corn grain	-	15	26
Barley grain	16	18	23
Cotton seed	-	8	11
Wheat bran	54	10.4	-
Cotton seed meal	6	-	5
Rapeseed meal	13	10	5.5
Soya bean meal	8.4	15	20
Fish meal	-	4	1.5
Corn gluten meal	-	4	2
Fat meal	-	4	2.5
Vitamin and mineral premix	1	1	1.2
Urea	0.3	-	-
$FeSO_4$	-	0.1	-
$CaCO_3$	0.3	-	-
DCP	-	0.3	0.4
NH_4Cl	-	1.7	-
NaCl	0.4	0.3	0.5
$NaHCO_3$	-	-	1.2
Mg_2O	0.6	0.45	-
Mycosorb	-	0.3	0.1
Protoxin	-	6	0.01
Calculated composition			
Protein (%)	12.97	16.09	18.87
NDF (%)	40.25	43.26	48.12
ADF (%)	38.29	32.23	30.26
Ca (%)	0.27	0.31	0.35
P (%)	0.26	0.16	0.27
Cr (ppm)	9	8	8

until their calves were weaned (Aragon et al., 2001). Reproductive responses to Cr may be related to its ability to increase insulin sensitivity. Insulin administration improved ovulation rate in energy-deprived heifers (Harrison and Randel, 1986). According to Kolmogorov-Smirnov test statistic (Petrie and Watson, 1999), Cr supplementation had no effect on insemination index (Table 3), probably as a result of lack of Cr supplementation effect on the level or sensitivity of insulin (Bunting, 1997). Brayan et al. (2004), Stahlhut (2004) and Yang et al. (1996) reported that Cr supplementation may improve fertility. However, Bonomi et al. (1997) and Pechova et al. (2003) reported that Cr supplementation has no significant effect on reproductive performance.

Clinical metabolic disorders and clinical puerperal complications

According to Kolmogrov-Smirnov test statistic (Petrie and Watson, 1999), using Cr supplementation has no effect on clinical metabolic disorders and clinical puerperal

Table 2. The effect of Cr-Met supplementation on the numbers of open days.

Treatment	Numbers of open days
Chromium	127[b]
Control	152.6[a]
SEM	10.35

[a-b] Means in the same column with no common superscripts are significantly different (p<0.05).

Table 3. The effect of Cr-Met supplementation on insemination index.

Trait	Insemination index
	0.048 [n.s]
Probability amount	1/000

n.s, not significant.

Table 4. The effect of Cr-Met on clinical metabolic disorders and clinical puerperal complications.

Trait	Ketosis	Acidosis	Fever milk	Placental retention	Displaced abomasum	Mastitis	Ovarian cysts	Endometritis
Static amount of K.S	0.218[n.s]	0.435 [n.s]	0.000[n.s]	0.218 [n.s]	0.218 [n.s]	0.435 [n.s]	0.218 [n.s]	0.245 [n.s]
Probability amount	1.000	0.991	1.000	1.000	1.000	0.991	1.000	1.000

n.s, not significant.

complications (Table 4). In order to evaluate the effect of Cr supplementation on metabolic disorders, a large number of experimental animals is required in the field of epidemiological studies. In the present study, it appears that the number of animals used was not adequate. The incidence of many metabolic disorders increased with parity or age. Some researchers reported a decrease in metabolic disorders by Cr supplementation in old cow (parity 3 and more). Because these cows had higher BCS, they had more tendencies for tissue mobilization, and when the high amount of energy was mobilized, the cows became prone to ketosis and fat livers (Mowat, 1996). In addition, the cows with high BCS probably had less sensitivity to insulin (NRC, 2001). In our experiment, because the experimental cows were young, it was observed that Cr supplementation had no effect on metabolic disorders. In the present research, there is a strong possibility that Cr supplementation had no effect on antibody production; consequently, puerperal complications were not affected by Cr supplementation (Table 4). The role of Cr supplementation on antibody production and an improvement of immune performance was reported by Burton et al. (1993), Chang et al. (1996) and Moonsie-Shageer and Mowat (1993).

In conclusion, the results of this study showed that supplemental chromium caused a decrease in the numbers of open days which was not statistically significant ($p < 0.05$), and had no effect on insemination index. Clinical metabolic disorders and clinical puerperal complications were not affected by chromium methionine supplementation. The results of this experiment showed that using chromium methionine supplementation in multiparous dairy cows diet may improve their reproductive performance in transition period.

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