African Journal of Biotechnology Vol. 11(93), pp. 16029-16033, 20 November, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.3432
ISSN 1684–5315

Full Length Research Paper

Reproductive performance by dairy cows fed supplemental chromium-methionine (Cr-Met) in transition period

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Accepted 10 April, 2012

This study was conducted to study the effect of supplemental chromium on reproductive performance of dairy cows. Thus, forty multiparous Holstein cows (parity 3) were allocated to two treatments and 20 replicates in a completely randomized design. In this study, treatments consisted of: control group, which received no chromium supplementation and treatment group, which received 6 g/day chromium from chromium methionine. The cows allocated to this experiment from week 3 prior to parturition until 9 weeks thereafter. Reproduction parameters consisted of: insemination index and numbers of open days, clinical metabolic disorders which include acidosis, milk fever, retained placenta and displaced abomasums, and also clinical puerperal complications consisting of: mastitis, endometritis and ovarian cysts were determined. Results indicate that Cr supplementation significantly causes 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 showed that chromium methionine supplementation in multiparous dairy cows diet may improve their reproductive performance in transition period.

Key words: Dairy cow, Chromium methionine, reproductive performance.

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} is known for its *in vivo* antioxidative activity and favourable effects on the stability of proteins and nucleic acids (Anderson, 1994). However, its most important metabolic effect consists in an enhancement of insulin activity by its presence in an organometallic molecule known as the glucose tolerance factor (GTF). 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 (Vincent, 2000). With Cr acting as a cofactor of insulin, Cr activity in the organism is parallel to insulin functions (Pechova and Pavlata, 2007). Chromium supplementation of 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 et al., 1994), further depleting Cr stores.

Most of the Cr present in animal tissues is bound in GTF. Data on the distribution of chromium in animal tissues is rather sporadic. Low concentrations, declining with age (Mertz, 1997), can be found in almost all tissues. In the man, the concentration is highest in lung tissue and decreases in the following order: liver → pancreas heart → striated muscles → kidney → spleen → brain (Lentner, 1981). Blood concentration does not parallel that of tissue stores (Underwood, 1977), but reflects exposure to chromium (Barceloux, 1999).

Cr enhances binding of insulin to cell membrane

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receptors and the optimisation of insulin activity results in better regulation of glucose uptake by cells, improved control of blood glucose concentration and maximization of the energetic potential (Pechova et al., 2002a). 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 exposed to physical strain (Pechova et al., 2002a).

Available data on Cr concentration in rations for farm animals is insufficient. Moreover, even rations containing Cr concentrations satisfying 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 the work was to assess the effect of dietary supplementation with Cr from chromium methionine, from five week (wk) preparturient through 12 wk postpartum on reproductive performance of dairy cows.

MATERIALS AND METHODS

Animal and treatments

Forty multiparous Holsteins (parity 3) housed in free stalls at the Mahyar kesht farm of Esfahan city of Iran country were randomly allocated across two treatment group: Twenty cows were supplemented once daily with 6 g/day Cr from Cr-Met via ball dough corn after the morning milking, whereas the other 20 cows received no Cr supplementation. Cows received treatments from 3wk prepartum (wk-3) through 9wk postpartum once daily (wk+9). From wk-3 to wk+9 a total mixed diet (NRC, 2001) was offered to all cows (*ad libitum* intake). Random samples were taken of these TMR diets which were sent to laboratory for analysis. Also the amount of chromium in water and diets were determined by atomic absorption system. The results are shown in Table 1.

Reproduction data

The assessment of the reproductive status was carried out by rectal palpation, vaginal and ultrasonographic examinations that were carried out from week two after parturition in weekly intervals to the confirmation of pregnancy. The following parameters were monitored: occurrence of clinical metabolic disorders (acidosis, ketosis, milk fever, retained placenta and displaced abomasum), clinical puerperal complications (mastitis, ovarian cyst and endometritis), and insemination index, number of open days.

Statistical analysis

Number of open days was analyzed by using General Linear Model Procedures of SPSS16 in the computer for a completely randomized design and twenty repeated using the following model. Duncan multiple range test was used to test significant differences in treatments. Also insemination index and clinical puerperal complications (mastitis, ovarian cyst and endometritis) were analyzed by Kolmogorov-Smirnov test statistic (Petrie and Watson, 1999).

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

Where, Yijk is the depended 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 DISCUSION

Reproduction parameters

The Cr supplementation was significantly decreased in the numbers of open days ($p < 0.05$) (Table 2). Decrease in open days in other studies was due to tissue mobilization and decrease weight loss at the beginning of milking. Cr supplementation reduced non essential fatty acids (NEFA) of plasma; it could be because of increase in insulin sensitivity or because of increase in dry matter intake which has been reported as a response to administration of organic chromium (Besong et al., 1996; Bryan et al., 2004; Stahlhut 2004; Yang et al., 1996). In another trial, feeding chromium methionine in transition period led to significantly decreased serum cortisol concentration ($p < 0.05$) (Khalili et al., 2011). Decreased serum cortisol concentration may result to increased insulin effects on reproductive performance.

Chromium plays an important role in the secretion of pregnancy specific proteins from the uterine endometrium which is helpful in preventing early embryonic death. Chromium exerts a significant influence on follicular maturation and luteinizing hormone (LH) release. It possibly leads to lower sperm count and decreased fertility and influences foetal growth and development (Tuormaa, 2000).

Chromium 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 the controls (Bryan et al., 2004).

Chromium has also affected reproduction in beef cows grazing pastures. Providing Cr in a free choice mineral improved pregnancy rate in beef cows. The improvement in reproduction was due to increased pregnancy rate in cows five years of age or younger. Chromium did not affect pregnancy rate in beef cows six years of age or older (Stahlhut et al., 2006b).The improved pregnancy rate was associated with much lower plasma NEFA concentrations at approximately 21 and 79 days postpartum with feeding Cr supplementation to dairy cows (Stahlhut et al., 2006a). Chromium supplementation reduced postpartum body weight loss in two and three-years old cows but not in older cows (Stahlhut et al., 2006b). Supplementation of Cr in a free choice mineral reduced

Table 1. Dry matter composition of basal diets fed to non lactation or lactation 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
Barely 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 been 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
MgO	0.6	0.45	-
Toxin binder (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)	5	4	7

NDF, Neutral detergent fiber; ADF, acid detergent fibre; DCP, digestible crude protein.

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 until their calves were weaned (Aragon et al., 2001). 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 level or sensitivity of insulin (Bunting, 1997).

Brayan et al. (2004), Stahlhut et al. (2004) and Yang et al. (1996) reported that Cr supplementation may improve fertility, but Bonomi et al. (1997) and Pechova et al. (2003) reported that Cr supplementation had non-significant effect on reproductive performance.

Clinical metabolic disorders and clinical puerperal complications

According to Kolmogrov-Smirnov test statistic (Petrie and Watson, 1999) using Cr-Met supplementation had no

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

Treatment	Numbers of open day
Chromium	115[b]
Control	140[a]
SEM	9.25

[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
Static amount of K.S	0.058[n.s]
Probability amount	1/000

n.s, = Not significant.

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

Trait	Ketosis	Acidosis	Fever milk	Placental retention	Displaced abomasum	Mastitis	Ovarian cyst	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.

effect on clinical metabolic disorders and clinical puerperal complications (Table 4).The incidence of many metabolic disorders increase with parity or age. Researchers have reported a decrease in metabolic disorders by Cr supplementation in old cow (parity 3 and more) (Mowat, 1996). Based on the fact that these cows have higher body condition scoring (BCS), they have more tendency for tissue mobilization and when the high amount of energy are mobilized, cows become prone to ketosis and fat livers (Mowat, 1996). In addition, cows with high BCS may have less sensitivity to insulin (NRC, 2001). In our experiment, because experimental cows were young, it was observed that Cr supplementation had no effect on metabolic disorders.

In our research there is a strong possibility that Cr supplementation had no effect on antibody production and consequently puerperal complications was not affected by Cr supplementation (Table 4). The role of Cr supplementation on antibody production and improved immune performance was reported by investigators (Burton et al., 1993; Chang et al., 1996; Moonsie-Shageer and Mowat, 1993).

In conclusion, the results of this study indicate that Cr supplementation significantly cause decrease in the numbers of open days ($p < 0.05$), 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 show that using chromium methionine (Cr-Met) supplementation in multiparous dairy cows diet may improve their reproductive performance in transition period.

ACKNOWLEDGEMENTS

This project was supported by the Islamic Azad University, Khorasgan branch, Isfahan, Iran and Sana Dam Pars Company Limited, Tehran, Iran on behalf of Zinpro Corporation, USA.

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