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Effect of dietary organic selenium on milk selenium concentration and antioxidant and immune status in midlactation dairy cows

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ABSTRACT

This study aimed to investigate the effects of the dietary selenium (Se) source on milk yield, milk Se concentration and antioxidant and immune status in dairy cows. Fourteen multiparous Holstein cows with similar dry matter intake (DMI), milk yield and parity were randomly divided into two groups with seven replicates in each group. The cows in both groups were fed basal diets supplemented with 0.3 mg Se/kg DM from sodium selenite or Se yeast, and the background Se level of the basal diet was 0.02 mg/kg DM. The experimental period lasted for 60 days. The results indicated that the DMI, milk yield and composition were not affected by the dietary Se source ($P > 0.10$). During the entire experimental period, Se yeast supplementation significantly increased the serum glutathione peroxidase activity and decreased the malondialdehyde content ($P=0.00$) compared with selenite. The serum selenoprotein P content (30 d), thioredoxin reductase and catalase activities (60 d), and total antioxidant capacity (60 d) were also higher ($P < 0.05$) with Se yeast supplementation than with selenite. Compared with selenite, organic Se supplementation increased the values of immunoglobulin (Ig) A and soluble CD4/soluble CD8 on day 30, soluble CD4 on day 60, and interleukin (IL)-1 during the trial ($P < 0.05$). However, other measures of immunity, such as IgM, IgG, soluble CD8, IL-2, IL-4, IL-6 and tumour necrosis factor, were not affected by the dietary Se source ($p > 0.10$). The total Se in the whole blood and milk were higher with Se yeast supplementation than selenite ($P < 0.05$), and the milk Se concentration was increased markedly over the duration of Se supplementation from day 30 to 60. These results suggested that Se yeast may be more effective than sodium selenite in improving the antioxidant status and increasing the whole blood and milk Se concentrations of dairy cows.

1. Introduction

Mastitis is an inflammatory reaction within the udder that causes major economic losses in the dairy industry, a decrease in the milk yield, and a reduction in milk quality (Boutet et al., 2003). The incidence of mastitis increases when the immune-defense mechanisms of the udder are impaired (Sordillo, 2005). Oxidative stress, induced by reactive oxygen species (ROS), is also believed to be the primary cause of various cattle diseases including mastitis (Karyak et al., 2011). Therefore, improving the antioxidant and immune status is an important measure for guaranteeing the health of dairy cows and improving the milk quality.

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Selenium (Se) was discovered by Berzelius in 1817 and has been recognized as an essential trace element for both animals and humans (Schwarz and Moltz, 1957; Stadtman, 1996; Hatfield et al., 2006). It was reported that sufficient Se in the diet increased the whole blood, erythrocyte and serum glutathione peroxidase (GSH-Px) activities and decreased the serum malondialdehyde (MDA) content (Rowntree et al., 2004; Xu et al., 2007), and thus improved the antioxidant status in dairy cows. Sufficient Se in the diet also improved the immune measurements and mammary health of cows (Cebra et al., 2003; Weiss, 2003; Mukherjee, 2008) and resulted in a reduction in the somatic cell counts and the incidence of mastitis of dairy cows (Smith et al., 1984). However, feed ingredients often cannot supply adequate Se for animals, and thus Se supplementation is now a common practice in animal nutrition.

Se supplements exist in two principal forms: inorganic mineral salts, such as sodium selenite and sodium selenate, and organic forms such as Se yeast, in which selenomethionine (SeMet) is the predominant form of Se. The Se supplement commonly used in the diet of dairy cows is sodium selenite because it is less expensive than organic Se. Doucha et al. (2009) reported that Se yeast is more bioavailable and safer than inorganic Se for improving the Se status of ruminants. Weiss (2005) in his review showed that, on average, Se yeast increased the whole blood GSH-Px activity more effectively than selenite, but that in other studies, there was no difference (Knowles et al., 1999; Calamari et al., 2010). In addition to GSH-Px, other selenoproteins, such as thioredoxin reductase (TrxR) and selenoprotein P (SelP), also possess antioxidative enzyme activities and play a key role in removing hydrogen peroxides and lipid hydroperoxides. in vitro studies have reported that Se supplementation significantly increased the TrxR activity in cultivated bovine aortic endothelial cells (Miller et al., 2001) and the SelP mRNA level in bovine mammary epithelial cells (Bruzelius et al., 2010). However, little is known about the effect of the Se source on the blood TrxR activity and the SelP content of dairy cows.

Additionally, little information is available about the effect of the selenium source on the immune response of dairy cows. Awadeh et al. (1998) reported that the plasma immunoglobulin (Ig) M concentration in beef cows receiving Se from Se yeast increased compared with the concentrations of those receiving the same amount of Se from selenite. However, other studies showed that the neutrophil function of cows (Weiss and Hogan, 2005), serum IgM and IgG concentrations of growing heifers (Kincaid and Cronrath, 2001) and plasma interleukin (IL)-1 and IL-2 levels of lambs (Qin et al., 2007) were not affected by the dietary Se source. The maximum legal dose of Se supplementation in the diet of dairy cows is 0.3 mg/kg DM within the United States (National Research Council, 2001), and both the inorganic and organic forms of Se are approved. Therefore, the present study aimed to compare the effects of the supplemented organic and inorganic Se at 0.3 mg/kg in the diet on the milk performance, milk Se concentration and antioxidant and immune measurements and to provide useful evidence supporting the application of organic Se in the diet of dairy cows.

2. Materials and methods

2.1. Animals, diets and experimental design

The experimental procedures for the dairy cows used in this trial were approved by the Animal Care and Use Committee of Inner Mongolia Agricultural University (Hohhot, Inner Mongolia, China). Fourteen multiparous Holstein cows averaging 550 ± 50 kg of BW, 17.3 ± 0.5 kg of dry matter intake (DMI)/d, 150 ± 10 days in milk, and 20.8 ± 0.5 kg of milk/d were randomly divided into two groups with seven replicates in each group. The experiment was conducted as a single-factor arrangement. Two different treatment groups were fed two sources of Se (supplemented with inorganic Se from sodium selenite or organic Se from Se yeast (SelenoSourceAF^{TM}2000; Diamond V, Mills Inc., USA) at 0.3 mg/kg DM). The experimental cows were fed as a total mixed ration (TMR). The Se concentration in the basal diet without Se supplementation was measured as 0.02 mg/kg DM. The ingredient and nutrient composition of the diets are presented in Table 1. The pretrial period was 14 d, and the experimental period lasted for 60 days.

2.2. Sampling procedures and measurements

Maize silage and Chinese wildrye hay and concentrate (300 g/sample) were collected monthly and analysed for the DM, crude protein (CP), calcium (Ca) and phosphorus (P) contents (AOAC, 2000), as well as the contents of neutral detergent fibre (NDF) and acid detergent fibre (ADF)

Table 1
Composition and nutrient levels of the basal diets of cows.

Composition	Content
Ingredient, %	
Maize silage	39.22
Chinese wildrye hay	18.83
Corn	15.74
Cottonseed meal	5.18
Dry distillers grains	10.83
Rapeseed meal	2.49
Corn germ meal	2.12
Corn gluten feed	2.30
Sodium bicarbonate	0.78
$CaCO_3$	0.31
$CaHPO_3$	0.78
Salt	0.90
Premix[a]	0.52
Chemical composition, g/kg DM	
NE_L[b], MJ/kg DM	6.34 ± 0.25
CP	135.2 ± 12.81
Ca	9.2 ± 0.6
P	6.1 ± 0.2
NDF	421 ± 18.1
ADF	252.0 ± 13.9
Se, mg/kg DM	0.02 ± 0.001

[a] Provided the following (per kg of diet DM): 3560 IU of VA, 1250 IU of vitamin D, 15 IU of vitamin E, 30 mg of Fe as ferrous sulphate, 40 mg of Mn as manganese sulphate, 10 mg of Cu as copper sulphate, 0.35 mg of I as iodine chloride and 0.2 mg of Co as cobalt chloride. Se was added in accordance with the experimental design.

[b] Calculated according to NRC (2001) based on the actual dry matter intake.