J. Dairy Sci. 100:1–9
https://doi.org/10.3168/jds.2017-12610

Hydroxy-selenomethionine: A novel organic selenium source that improves antioxidant status and selenium concentrations in milk and plasma of mid-lactation dairy cows

P. Sun,*[1] J. Wang,*[1] W. Liu,* D. P. Bu,*†‡[2] S. J. Liu,§ and K. Z. Zhang#
*State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, 100193, China
†Chinese Academy of Agricultural Sciences-World Agroforestry Center (CAAS-ICRAF) Joint Lab on Agroforestry and Sustainable Animal Husbandry, World Agroforestry Centre, East and Central Asia, 100081, Beijing
‡Hunan Co-Innovation Center of Animal Production Safety, CICAPS, Hunan, 410128, China
§China Feed Industry Association, Beijing, 100125, China
#Beijing Sino Farm, Beijing, 100028, China

ABSTRACT

This study aimed to evaluate the effect of hydroxy-selenomethionine (HMSeBA), a novel organic selenium (Se) source, on milk performance, antioxidative status, and Se concentrations in the milk and plasma of mid-lactation dairy cows compared with that of sodium selenite (SS). Fifty mid-lactation dairy cows with similar days in milk, milk yield, and parity received the same basal diet containing 0.06 mg of Se/kg of DM. They were assigned to 1 of 5 treatments according to a randomized complete block design: negative control (without Se supplementation), SS supplementation (0.3 mg of Se/kg of DM; SS-0.3) or HMSeBA supplementation (0.1, 0.3, or 0.5 mg of Se/kg of DM: SO-0.1, SO-0.3, and SO-0.5, respectively). The experiment lasted for 10 wk, including a pretrial period of 2 wk. The results indicated that neither Se supplementation nor Se source affected dry matter intake, milk yield, milk composition, or blood biochemical parameters, except for milk fat percentage. Simultaneously, milk fat percentage and milk fat yield increased linearly as the quantity of HMSeBA supplementation was increased. Production of 4% FCM and ECM was elevated linearly as dietary HMSeBA increased. The SO-0.3 group showed higher serum activity of glutathione peroxidase, total antioxidant capacity, and superoxide dismutase than the SS-0.3 group, but malondialdehyde content was not affected by Se source. Furthermore, HMSeBA supplementation linearly increased the activities of serum glutathione peroxidase and superoxide dismutase, but decreased malondialdehyde content. Compared with the SS-0.3 group, the SO-0.3 group showed augmented concentrations of total Se in milk and plasma, and total Se milk-to-plasma concentration ratio. In addition, increasing doses of HMSeBA linearly increased the concentrations of total Se in the milk and plasma. This study demonstrates that HMSeBA improves antioxidant status and increases milk and plasma Se concentrations more effectively than SS, indicating that HMSeBA could replace SS as an effective organic Se source for lactating dairy cows.
Key words: hydroxy-selenomethionine, antioxidant status, milk and plasma Se concentration, dairy cow

INTRODUCTION

Reactive oxygen species (**ROS**) are produced during normal cellular respiration, in which energy is generated to meet cellular needs (Prasad, 2014). The ROS generated are neutralized by antioxidant defense systems to maintain normal physiological status (redox homeostasis). When the production of ROS overwhelms the capacity of these systems, oxidative stress develops. Overproduction and accumulation of ROS predisposes animals to metabolic diseases (Gong and Xiao, 2016); therefore, antioxidant status must be improved to remedy the problems associated with oxidative stress. During dairy cow lactation, when a large amount of energy is required for rapid development of the mammary gland and for synthesis of large quantities of milk constituents, dairy cows are usually exposed to oxidative stress (Gong and Xiao, 2016). The antioxidant capacity of dairy cows declines during early lactation, and therefore the risk of oxidative stress increases (Castillo et al., 2005).

Selenium is a trace element that is necessary to maintain antioxidant status in humans and animals and which often requires supplementation in the diet of production animals (Schwarz and Moltz, 1957). Previous studies show that providing sufficient Se in the diet of dairy cows improves their antioxidant status, increases

Received January 17, 2017.
Accepted August 2, 2017.
[1]These authors contributed equally.
[2]Corresponding author: budengpan@126.com

the activity of glutathione peroxidase (**GSH-Px**), decreases the malondialdehyde (**MDA**) concentration in plasma, and reduces SCC in milk (Stewart et al., 2012). Due to the contrasting soil Se levels in different parts of China, feed produced in areas deficient in Se does not fulfill the dietary requirement for Se (Zheng et al., 1982). Therefore, supplementation of the diet of dairy cows with Se is important to avoid deficiency.

Both inorganic and organic forms of Se are common in dietary supplements on dairy farms. Because of their low prices, inorganic forms of Se [sodium selenite (**SS**) and sodium selenate] are widely used. However, compared with inorganic Se, organic Se has a higher absorption rate (Boldizarova et al., 2005), greater biological activity (Ortman and Pehrson, 1999), a higher rate of tissue accumulation (Briens et al., 2014), and lower toxicity. Organic and inorganic forms of Se are metabolized differently in the body (Calamari et al., 2010). Selenium yeast (**SY**) improves antioxidant status (Gong et al., 2014), increases whole blood and milk Se concentrations (Slavik et al., 2008), and improves the Se status of ruminants more effectively than SS (Doucha et al., 2009). Calamari et al. (2010) concluded that a greater proportion of Se reached the milk from the circulation when SY was provided to cows, rather than SS.

Hydroxy-selenomethionine (**HMSeBA**), namely Selisseo (**SO**, Adisseo France S. A. S., Antony, France), is an organic bioavailable source of Se for all animals, which can be added to feed premixes (Briens et al., 2013). In contrast to selenomethionine, which is the predominant form of Se in SY (Korhola et al., 1986), HMSeBA is synthetic R,S-2-hydroxy-4-methylselenobutanoic acid, possessing a hydroxyl group instead of an amino group on its second carbon atom. The European Commission has approved the use of HMSeBA for animals as a feed additive (EFSA, 2013a). To date, the benefits of HMSeBA have been described in monogastric animals, such as broilers (Briens et al., 2013, 2014), layers (Jlali et al., 2013), and pigs (Jlali et al., 2014), but not in ruminants. We hypothesized that the use of HMSeBA as a feed additive may be effective as a novel source of Se for dairy cows. Therefore, the objectives of the present study were to evaluate the effects of different sources of Se and different doses of HMSeBA on milk production, biochemical parameters, and serum antioxidant status, as well as Se concentrations, in the milk and plasma of dairy cows.

MATERIALS AND METHODS

This study was conducted at Beijing Sino Farm (Beijing, China). All procedures were conducted using protocols approved by the Institute of Animal Science, Chinese Academy of Agricultural Sciences (Beijing, China). All animals used in the current study were raised according to standards established by the Institute of Animal Science, Chinese Academy of Agricultural Sciences (Beijing, China). All cows were housed in a freestall barn with free access to fresh water. Total mixed ration was fed ad libitum to all cows. Before the commencement of the feeding trial and throughout the experimental period, the health condition of the cows was monitored and recorded.

Sources of Se

Two types of Se were used in this study. The HMSeBA was provided by Adisseo Life Science Co. Ltd. (Shanghai, China). The minimum contents of Se and HMSeBA were 2.0 and 5.0%, respectively. The SS was provided by Henan XiuCang Chemical Products Co. Ltd. (Henan Province, China).

Cows, Diets and Experimental Design

The current study was performed as a randomized complete block design. Fifty multiparous Holstein cows (DIM = 153 ± 18; milk yield = 28.9 ± 1.5 kg/d; and parity = 2.4 ± 1.1) were assigned to 1 of 5 treatments (n = 10), which were balanced for DIM, milk yield, and parity. All cows received the same TMR without Se supplementation. The background Se concentration in the TMR was 0.06 mg/kg on a DM basis. The dietary supplements differed only in the source and amount of Se they contained, specifically negative control (without Se supplementation), SS supplementation (0.3 mg of Se/kg of DM; **SS-0.3**), or HMSeBA supplementation (0.1, 0.3, and 0.5 mg of Se/kg of DM: **SO-0.1**, **SO-0.3**, and **SO-0.5**, respectively).

The TMR (Table 1) without Se supplementation (Beijing Sanyuan Seed Technology Co. Ltd., Beijing, China) was formulated to meet nutrient requirements according to NRC (2001). A computerized monitoring system (RIC system, Insentec B.V., Marknesse, the Netherlands) was used as described previously (Zhou et al., 2015). Each cow had an electronic ear tag that gave access to a single feed tank, and the RIC system recorded its daily feed intake. Feed was provided 3 times a day, after each milking, at 0730, 1400, and 2030 h, with a 5 to 10% refusal rate. The refusals were removed every morning. The HMSeBA and SS were weighted and separately packed for each cow before the start of the experiment. The appropriate quantity of HMSeBA or SS was mixed with 100 g of ground corn during milking and fed with the TMR during the morning feed. The pretrial period was 2 wk and the experimental period lasted 8 wk.