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Effect of feed selenium supplementation on milk selenium distribution and mozzarella quality

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ABSTRACT

In the present study, the effect of feed Se supplementation on the Se content of raw milk and mozzarella cheese as well as the effect on cheese quality and functionality were determined. The Se milk was produced by supplying dairy cow feed with Se yeast (0.3 mg of Se/kg of dry matter), resulting in a Se concentration in milk of 35.81 μg/L. The fat, casein, and whey protein of Se milk were separated by ultracentrifugation, and the Se content was determined by atomic absorption spectroscopy. The Se distribution in different milk fractions of fat, casein, and whey protein were 9.82, 45.56, and 44.62%, respectively. The Se mozzarella cheese was made by Se milk, and the composition and texture of Se cheese did not significantly differ from that of the control. However, the functional properties (meltability, flowability, and stretchability) of the Se cheese were better after 8 wk of storage. Moreover, the pH and water activity were lower in Se cheese, which decreased the total plate count. The Se content in mozzarella cheese was 4 fold higher than that in milk, and Se was found in the whey, hot water, and brine collected during cheesemaking. Organic and inorganic Se was found in the Se cheese after 8 wk of storage, and most Se peptides detected after storage were Se-Met and Se-Cys. The results of this study show that feed Se supplementation can improve the Se content of milk and cheese without affecting mozzarella cheese quality.
Key words: dairy cattle, selenium supplementation, selenium distribution, Mozzarella

INTRODUCTION

Selenium is an important trace element, and Se deficiency has been associated with negative effects on human and animal health (Hatfield et al., 2014; Alfthan et al., 2015). The adult human recommended dietary allowance for Se is approximately 55 μg/d, and the highest tolerable intake level has been set at 400 μg/d. Interest in the administration of Se supplements has increased in recent years because of its bioactivity, including its role as an antioxidant against free radicals, its cancer-preventive properties, and its inhibition of glutathione peroxidase and other reductases (Albanes et al., 2014; Shaheen et al., 2015; Speckmann and Grune, 2015).

The population in many places around the world, such as those of China, Russia, and New Zealand, is deficient in Se (Rayman, 2000). The concentration of Se in plants and animals varies widely and depends on the Se content and characteristics of the soil. Therefore, methods to increase Se intake by preparing Se-enriched foods is a current subject of interest. Many studies have attempted to enrich different food products with Se, such as yeast, plants (rice, garlic, green onions, sesame, and broccoli; Pophaly et al., 2014; Yasin et al., 2015), and animal products (meat, milk, and egg; Calamari et al., 2010; Lin, 2014). Food can be supplemented with Se in 2 forms: inorganic forms, such as selenite and selenate, or organic forms, such as Se yeast and Se grain. A meta-analysis of the effect of oral Se supplementation on milk Se concentration in cattle has shown that cows supplemented with Se yeast produced milk with higher Se concentrations than those supplemented with inorganic forms of Se (Ceballos et al., 2009). The inorganic and organic Se forms in dietary supplements are metabolized differently in animals. Organic Se, such as Se-Met, is actively transported through and absorbed in the intestine and nonspecifically incorporated into body proteins in place of Met during protein synthesis, providing a means of reversible Se storage in organs and tissues (Schrauzer, 2003). In contrast, inorganic Se is absorbed via passive diffusion, and little is retained in tissue reserves. Consequently, a large proportion of inorganic Se is excreted in the feces and urine. Recently, Se yeast has been authorized for use within the Euro-

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pean Union as a feed additive (European Commission, 2006).

Milk and fermented milk are vital components of human nutrition and usually present in traditional meals. Milk is regularly consumed in moderate amounts and affordable. In this regard, Se-enriched milk and its fermentation products are interesting approaches to increase the human intake of organic compounds, such as Se. Several studies have been undertaken to produce Se-enriched fermented milk product by using microorganisms that biotransform inorganic Se into organic its forms, such as Se-Cys and Se-methylselenocysteine (Alzate et al., 2008; Alzate et al., 2010). Other studies have attempted to producing Se-enriched milk and fermented milk products by feed Se supplement (Moschini et al., 2010; Deng et al., 2015).

Although some studies have intended to produce Se-enriched cheese (Gulbas and Saldamli, 2005; Pechova et al., 2008; Moschini et al., 2010), the effect of this enrichment on the mozzarella cheese quality and the Se content and distribution during cheesemaking and storage remains unclear. Furthermore, whether or not Se-fortified milk or dairy products produced by animals fed Se can be used in populations traditionally deficient is still in need of further study. Therefore, our study examined the Se content and distribution in milk and mozzarella cheese in response to feed Se supply and effect of Se milk on mozzarella cheese quality.

MATERIALS AND METHODS

Milk Sampling

The milk samples used in our study were obtained from a local dairy farm (Qiaosi dairy farm, Hangzhou, Zhejiang Province, China). Two groups of 16 multiparous Holstein cows in mid lactation were selected: 1 group of cows received the basal diet containing a supply of organic Se (0.3 mg of Se/kg of DM, Novus, St. Charles, MO) according to our previous research (Y. Li and J. X. Liu, Institute of Dairy Science, College of Animal Science, Zhejiang University, Hangzhou, China; unpublished data), and the other group without feed Se supplement was used as control. Ingredients and chemical compositions of diets are shown in Table 1. Diets were formulated according to nutrient requirements for lactation Holstein cows weighing 600 kg and producing 30 kg/d of milk.

Milk samples from 2 groups were collected during mid lactation after a 2-mo experiment, and the milk components were analyzed by infrared spectroscopy using a Milko Scan FT 120 (Foss Electric, Hillerød, Denmark). The fat, casein, and whey in the milk were separated by ultracentrifugation (200,000 × g) for 60 min at 4°C. The samples were frozen at −20°C until analysis.

Cheesemaking

The milk used for cheesemaking was sampled from the same place and at the same time from cows with or without feed Se supply. The raw milk (30 L) was standardized to a protein-to-fat ratio of 3.1:3.5 by partial skimming, and the milk was pasteurized at 63°C for 30 min, followed by cooling to 35°C. Mozzarella cheese was made as described in a previous study with some modifications (Sheehan and Guinee, 2004). The milk was inoculated with a starter culture TCC-3 (Chr. Hansen, Horsholm, Denmark). When the pH of the milk had decreased by 0.1 pH units, chymosin stamix 1150 (Chr. Hansen) was added. After 30 min, the curd was cut with 1-cm knives and allowed to heal for 15 min. The

Table 1. Ingredients and composition (% of DM, unless otherwise specified) of basal diets used in the experiment (n = 8)

Item	Content
Ingredient	
Corn silage	17.3
Chinese ryegrass[1]	7.0
Corn stover (pelletized)[1]	15.0
Ground corn	14.8
Steam-flack corn	7.4
Barley	4.9
Soybean meal	12.3
Cottonseed meal	4.9
Beet pulp	8.5
Beer refusal	2.8
Calcium carbonate	0.2
Premix[2]	4.9
Chemical composition	
DM (%)	50.5 ± 1.24
OM	92.5 ± 0.48
CP	14.9 ± 0.43
NDF	41.5 ± 2.40
ADF	24.6 ± 1.50
NFC[3]	34.6 ± 2.25
Ca	0.68
P	0.46
NE_L[4] (Mcal/kg of DM)	1.57
Se (mg/kg of DM)	0.09

[1]Compositions (% of DM) are as follows (n = 5): Chinese ryegrass hay: OM = 92.3, CP = 7.72, NDF = 67.5, ADF = 42.6, and NFC = 16.5; corn stover (pelletized): OM = 90.0, CP = 6.0, NDF = 56.8, ADF = 26.7, and NFC = 28.8.

[2]Formulated to provide (per kg of DM): 10 g of CP, 150 g of ether extract, 60 g of crude fiber, 70 g of Ca, 13 g of P, 100 g of salt, 30 g of Mg, 15 g of K, 10 g of Met, 260 mg of Cu, 260 mg of Fe, 1,375 mg of Zn, 500 mg of Mn, 112,000 IU of vitamin A, 29,500 IU of vitamin D_3, and 700 IU of vitamin E.

[3]NFC = 100 − % NDF − % CP − % ether extract − % ash.

[4]Calculated based on China Ministry of Agriculture (2004).