J. Dairy Sci. 89:3544–3551

Selenium Supplementation of Lactating Dairy Cows: Effect on Selenium Concentration in Blood, Milk, Urine, and Feces

D. T. Juniper,* R. H. Phipps,*[1] A. K. Jones,* and G. Bertin†
*Centre for Dairy Research, School of Agriculture, Policy and Development, University of Reading, RG6 6AR Reading, UK
†Alltech France, EU Regulatory Department, 14 Place Marie-Jeanne Bassot, 92300 Levallois-Perret, France

ABSTRACT

The objectives were to determine effects of graded levels of selenized yeast derived from a specific strain of *Saccharomyces cerevisiae* (CNCM I-3060) on animal performance and in selenium concentrations in the blood, milk, feces, and urine of dairy cows compared with sodium selenite; and to provide preliminary data on the proportion of selenium as selenomethionine in the milk and blood. Twenty Holstein cows were used in a 5×5 Latin square design study in which all cows received the same total mixed rations, which varied only in source or concentration of dietary selenium. There were 5 experimental treatments. Total dietary selenium of treatment 1, which received no added selenium, was 0.15 mg/kg of dry matter, whereas values for treatments 2, 3, and 4, derived from selenized yeast, were 0.27, 0.33, and 0.40 mg/kg of dry matter, respectively. Treatment 5 contained 0.25 mg of selenium obtained from sodium selenite/kg of dry matter. There were no significant treatment effects on animal performance, and blood chemistry and hematology showed few treatment effects. Regression analysis noted significant positive linear effects of increasing dietary selenium derived from selenized yeast on selenium concentrations in the milk, blood, urine, and feces. In addition, milk selenium results indicated improved bioavailability of selenium from selenized yeast, compared with sodium selenite. Preliminary analyses showed that compared with sodium selenite, the use of selenized yeast increased the concentration of selenomethionine in the milk and blood. There was no indication of adverse effects on cow health associated with the use of selenized yeast.

Key words: dairy cow, selenized yeast, sodium selenite, selenomethionine

INTRODUCTION

Selenium is recognized as an essential trace element, and its deficiency has been associated with impaired growth, fertility, and health in farm livestock (Schwarz and Foltz, 1957; Weiss et al., 1990). Selenium is also an essential nutrient for human health, and its role has been reviewed recently (Rayman, 2000, 2004). Rayman reported that between 1975 and 1995, selenium intake in the United Kingdom decreased from around 60 to 34 μg/d per person, which means that the current intake is about half of the UK Reference Nutrient Intake. This decline has caused concern because suboptimal selenium intake is associated with a number of serious health issues, including reduced immune function, cardiomyopathy, depressed mood, and increased incidence of cancer.

Although meeting dietary selenium requirements is an important nutritional requirement for livestock, mineral supplementation may also enhance the nutritional quality of the livestock product. In the European Union only inorganic sources of selenium, sodium selenate and sodium selenite (**SS**), are currently approved as feed additives, with a maximal legal dose rate of 0.5 mg of selenium/kg of DM (Ministry of Agriculture, Fisheries and Food, 2000). This value is higher than the limit of 0.3 mg of selenium/kg of DM set by FDA regulations in the United States, where both inorganic and organic sources of selenium, such as selenized yeast (**SY**), are approved.

A number of studies reviewed by Weiss (2005) and recent work reported by Givens et al. (2004) have established that, compared with inorganic sources of selenium, the use of SY resulted in a large and significant increase in milk selenium concentration, which was suggested as one route for increasing selenium intake in humans in areas where selenium intake was below optimum.

The majority of selenium in body tissues and fluids is present as either selenocysteine (**SeCys**), which functions as an active center for selenoproteins, or selenomethionine (**SeMet**), which is incorporated into general proteins and acts as a biological pool for selenium (Suzuki and Ogra, 2002). Early work by Allen and Miller (1980) studied the distribution and binding of additional selenium^{75} in goat and cow milk. More recent studies have shown that selenium absorption occurs in the small intestine and that although SeMet is absorbed

Received October 3, 2005.
Accepted April 28, 2006.
[1]Corresponding author: r.h.phipps@reading.ac.uk

via the methionine transporter system, the absorption of SS is less efficient and occurs mainly by passive diffusion (Weiss, 2003). Further work has reported that irrespective of source, selenium must undergo a metabolic transformation prior to its assimilation into SeCys and subsequent incorporation into selenoproteins. However, no such intermediate step is necessary for the incorporation of SeMet into general proteins. Although improvements in analytical methodology can provide the opportunity to determine the contribution of specific selenium fractions in livestock products, very little information has been published in this area.

The aims of the current study were 2-fold: The first was to determine the effect of an increasing level of SY on animal performance and to determine selenium concentrations in the blood, milk, feces, and urine of high-yielding Holstein dairy cows, compared with a standard inclusion of SS; and the second was to provide preliminary data comparing the proportion of Se incorporated as SeMet in the milk and blood of animals receiving either SS or SY at comparable dietary selenium concentrations.

MATERIALS AND METHODS

Cows, Experimental Design, and Diets

The work was conducted under the authority of the UK Animals (Scientific Procedures) Act 1986 (Home Office, 1986) and under the control of staff holding appropriate licenses under the Act. All cows were housed in cubicle yards with sawdust for bedding and with ad libitum access to potable water.

Twenty multiparous Holstein cows, which had completed 54 ± 8.5 DIM, and with an initial BW of 647 ± 76 kg, and producing 38.1 ± 2.8 kg/d of milk yield were used in a 5 × 5 Latin square design feeding trial made up of 4 squares and 5 periods, with each period lasting 5 wk. The design was balanced for residual effects of treatments in the succeeding period. All cows received the same TMR, which contained corn silage, grass silage, cracked wheat, soybean meal, rapeseed meal, and minerals at 375, 125, 250, 135, 100, and 15 g/kg of total dietary DM, respectively. The cracked wheat, soybean meal, and rapeseed meal were blended to produce a concentrate supplement that was added as a single component to the TMR. The TMR varied only in the source or concentration of dietary selenium. There were 5 experimental treatments: The total dietary selenium of treatment 1 (**T1**), with no added selenium, was 0.15 mg of selenium/kg of DM, whereas the values for treatments 2, 3, and 4 (**T2**, **T3**, **T4**) were, respectively, 0.27, 0.33, and 0.40 mg of selenium derived from SY/kg of DM. Treatment 5 (**T5**) contained 0.25 mg of selenium derived from SS/kg of DM.

The mineral supplements used (Dairy Direct International, Ashford, Kent, UK) were based on a commercially available product and contained, on a DM basis, 270 g/kg calcium, 40 g/kg phosphorus, 60 g/kg magnesium, 40 g/kg sodium, 50 mg/kg cobalt carbonate, 500 mg/kg calcium iodate, 4,000 mg/kg manganese oxide, 5,000 mg/kg zinc oxide, 1,500 mg/kg cupric sulfate, 15 mg/kg SS, and 500,000, 100,000, and 500 IU/kg of vitamin A, D_3, and E. The mineral supplement produced for use in T1 to T5 was identical to the commercial supplement described above except that the selenium was replaced with 0, 0.15, 0.30, or 0.45 mg of selenium derived from SY (Sel-Plex; Alltech, Nicholasville, KY)/kg of total diet DM for use in T1, T2, T3, and T4, respectively, and 0.15 mg of selenium derived from SS/kg of DM for use in T5.

On a given date, the 20 cows were allocated to the 5 treatments on the basis of milk yield, parity, calving date, and BW. A predesigned blocking matrix was used to determine the treatment to which animals were assigned. For animals to be accepted within a block, they had to have calved within 28 d of each other, have milk yields and BW within 3 kg/d and 50 kg (as measured in the 2 previous wk), and be of the same parity. Each treatment period lasted 5 wk, with wk 1 to 4 being for adaptation and wk 5 being for data collection and analysis.

Sampling Procedures and Measurements

Feed Analyses. In wk 5 of each period, daily samples (250 g/sample) of corn silage (36.9% DM), grass silage (27.3% DM), and concentrate supplement were collected and frozen (–20°C). At the end of the study, the samples for each period were bulked and then subsampled to provide a single sample for each ration component for each period. Silage samples were analyzed for a full range of nutritional and fermentation characteristics (Natural Resources Management, Bracknell, UK). Oven-dried (60°C until static weight) silage samples were analyzed for DM, CP, NDF, starch, and water-soluble carbohydrates using near-infrared spectroscopy (Foss 5000 NIR systems; Foss Electric, York, UK). The ME concentrations for grass silage, corn silage, and concentrate supplement were estimated (Givens et al., 1995; Offer et al., 1996). Gas chromatography (Agilent 6890 Series GC system; Agilent Technologies, Inc., Palo Alto, CA) was used to determine silage fermentation characteristics. The concentrate supplement was analyzed for DM, CP, NDF, starch, water-soluble carbohydrates, oil, and ME content using wet chemistry methods (Ministry of Agriculture, Fisheries and Food, 1993).

The results of the analyses obtained for the silages and the concentrate supplements were used to calculate