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Effect of an injectable trace mineral supplement containing selenium, copper, zinc, and manganese on immunity, health, and growth of dairy calves

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ABSTRACT

The objective of this study was to evaluate the effect of 2 subcutaneous injections of a multimineral preparation, each containing 60 mg of zinc, 10 mg of manganese, 5 mg of selenium, and 15 mg of copper at 3 and 30 d after birth on immunity, health, and growth of dairy calves during the preweaning period. The study was conducted in upstate New York in 2 commercial dairy farms. A total of 790 Holstein heifer calves were randomly allocated at birth into 1 of 2 treatments: trace mineral supplement (TMS) treated or control. Blood samples were collected at 3, 14, and 35 d after birth to evaluate glutathione peroxidase (GPx) activity, superoxide dismutase (SOD) activity, haptoglobin, and neutrophil and monocyte function. Incidence of diseases and average daily gain was evaluated in the first 50 d of life. At 14 d of life, TMS-treated calves had increased neutrophil activity compared with control calves. Moreover, TMS-treated calves had greater GPx activity on d 14 after birth than control calves. The TMS treatment reduced the incidence of diarrhea (TMS = 41.7% vs. control = 49.7%) and combined incidence of pneumonia or otitis or both (TMS = 41.7% vs. control = 49.1%). Additionally, GPx was greater for calves diagnosed with otitis at d 35 after birth. However, calves diagnosed with pneumonia had decreased GPx activity at d 35 after birth. Serum SOD and haptoglobin concentrations were not affected by treatment or disease. Moreover, no effects were observed on average daily gain and survivability between TMS-treated and control calves during the preweaning period. Supplementation with trace minerals at 3 and 30 d of life increased neutrophil function and GPx activity and reduced the incidence of health disorders.

Key words: trace mineral, dairy calf, neutrophil function, diarrhea

INTRODUCTION

Dairy replacement rearing success or failure is dependent on several complex and interrelated factors. Newborn calf health and growth can be impaired by poor maternal health (Lundborg et al., 2003), dystocia (Lombard et al., 2007), colostrum deprivation (Weaver et al., 2000), and poor calf nutrition (Ollivett et al., 2012). In the modern dairy industry, calves are reared artificially and early nutritional programs have been extensively studied to improve their performance during the preweaning period (Soberon et al., 2012). The physiological processes of a livestock animal, including the immune system, can be largely influenced by the availability of nutrient and trace minerals that are essential for multiple biochemical processes, including immune response, cell replication, and skeletal development, and are particularly relevant for the newborn (Carroll and Forsberg, 2007).

Studies that evaluate trace mineral depletion or supplementation focus on critical times in calves' lives and evaluate the effects of factors such as transportation (Crookshank et al., 1979), stress (Galyean et al., 1999), and diseases (Orr et al., 1990). For adult cattle, stress during the transition period can affect trace mineral status (zinc) and immune suppression can lead to greater susceptibility to diseases (Enjalbert et al., 2006). Likewise, stress can affect trace mineral status in dairy calves. Nockels et al. (1993) reported that calves under induced stress (intramuscular injections of ACTH) reduced their ability to retain trace minerals. An injectable trace mineral solution containing Zn, Cu, Mn, and Se was reported to increase liver concentrations of Cu and Se for at least a 15-d period, and increased plasma Zn and Mn for several hours in Angus and Simmental steers (Pogge et al., 2012).

Metabolic demands associated with stress and nutritional deficiency can lead to an increased production of reactive oxygen species (**ROS**; Sordillo and Aitken, 2009). When the production of ROS exceeds the antioxidant defense mechanisms present in the body, animals develop oxidative stress. Reactive oxygen species can initiate lipid peroxidation and cause cellular damage to tissues. Immune cells are particularly sensitive to

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oxidative stress because their membranes contain high concentrations of PUFA that are very susceptible to peroxidation, and produce large amounts of ROS when stimulated (Spears and Weiss, 2008). Several trace minerals are required for functioning of enzymes involved in the antioxidant defense system and may also affect immune cells via mechanisms distinct from antioxidant properties (Spears, 2000).

The role of early postnatal supplementation with injectable trace minerals on the immune response of newborn calves has not been investigated. Therefore, the objectives of this study were to evaluate the effect of supplementation of an injectable multimineral supplement containing Zn, Mn, Se, and Cu at 3 and 30 d after birth on peripheral blood neutrophil and lymphocyte function, oxidative stress markers, diseases (diarrhea, pneumonia, and otitis), and growth of Holstein heifer calves during the preweaning period.

MATERIALS AND METHODS

The study was conducted in 2 commercial dairy farms located near Ithaca, New York, from February to December, 2012. Farms were chosen because of their relationship with the Cornell University Ambulatory Clinic. Farm A was milking approximately 2,800 cows and farm B was milking approximately 1,600 cows.

Colostrum management was similar in both farms. Colostrum from primiparous and multiparous cows was pooled and refrigerated. Calves from farm A were fed approximately 4 L of raw colostrum within 4 h of birth at once by esophageal feeder (Oral Calf Feeder Bag with Probe; Jorvet; Jorgensen Laboratories, Loveland, CO). Calves from farm B were fed 2 L of raw colostrum within 2 h and another 2 L approximately 6 h later.

Both study farms had similar calf-rearing systems, which were individual pens in a greenhouse-type barn, positive ventilated, with individual pen dimensions of 1.5 m wide by 2 m long. The individual pens were isolated by plastic panels and bedded with a 0.5-m-deep gravel base that was covered with straw. Farm A and B had the same feeding system: calves were fed a total of 6 L of pasteurized (72°C for 15 s; T-600 and T-300; Goodnature Products Inc., Orchard Park, NY) nonsalable milk divided equally twice per day (0630 and 1700 h). Water and calf starter diets were offered ad libitum starting at d 3 of life to all calves in farms A and B. The starter composition for both farms is described in Table 1.

Table 1. Nutrient composition of calf starter diets for farms A and B

	Starter diet	
Composition	Farm A	Farm B
DM (%)	82.1	90.9
CP (% of DM)	19.8	22.9
NDF (% of DM)	29.4	31.8
ADF (% of DM)	15.7	14.1
TDN (% of DM)	72	77
Ca (% of DM)	0.99	0.94
P (% of DM)	0.64	0.78
Mg (% of DM)	0.43	0.35
K (% of DM)	1.40	1.01
Na (% of DM)	0.35	0.39
S (% of DM)	1.28	0.35
Fe (mg/kg)	398	258
Zn (mg/kg)	65	111
Cu (mg/kg)	20	22
Mo (mg/kg)	66	100

Study Design, Treatments, Blood Sampling, and Data Collection

A total of 790 calves were randomly allocated into the 2 treatments: trace mineral supplement (**TMS**) treatment or control. Randomization was completed using the random number function in Excel software (Microsoft Corp., Redmond, WA). Calves allocated into the TMS treatment received two 1-mL subcutaneous injections (60 mg of Zn, 10 mg of Mn, 5 mg of Se, and 15 mg of Cu; Multimin North America Inc., Fort Collins, CO) at 3 and 30 d after birth. Calves allocated into the control group were left untreated. Body weight was measured weekly in both farms using a WayPig 15, 1.6-m (62-inch) digital scale (WayPig; Vittetoe Inc., Keota, IA) from birth until weaning, which occurred at 50 d of life.

Blood collection was performed via jugular venipuncture using an 18-gauge by 3.8-cm needle in 2 individual vacuum tubes: a 10-mL vacuum tube (Becton, Dickinson and Co., Franklin Lakes, NJ) without anticoagulant for serum and an 8-mL heparinized vacuum tube (Becton, Dickinson and Co.) for plasma. Serum was harvested following centrifugation at 2,000 × *g* for 15 min at 4°C and plasma was harvested after centrifugation at 1,000 × *g* for 10 min at 4°C. Serum and plasma samples were stored at −80°C. Blood was sampled on d 3 (immediately before treatment administration), 14, and 35 after birth to evaluate glutathione peroxidase (**GPx**), superoxide dismutase (**SOD**), and haptoglobin (**Hp**). Additionally, serum IgG concentration was measured only on d 3.

A random subset of serum samples from 10 calves (5 for treatment) were sent to Veterinary Diagnostic Laboratory, Iowa State University (Ames) for analysis of Ca, Cu, Fe, K, Mg, Mn, Mo P, Se, and Zn. Blood mineral