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The effect of source of supplemental dietary calcium and magnesium in the peripartum period, and level of dietary magnesium postpartum, on mineral status, performance, and energy metabolites in multiparous Holstein cows

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ABSTRACT

The objective of this study was to determine the effects of feeding different supplemental sources of Ca and Mg in the peripartum period, and different dietary levels of Mg postpartum, on plasma mineral status, performance, and aspects of energy metabolism in transition dairy cows. Multiparous Holstein cows (n = 41) were used in a completely randomized design with a 2 × 2 factorial arrangement of treatments starting at 28 d before expected parturition. Main effects were source assignments (CS = common sources of supplemental Ca and Mg, or MA = a blend of common and commercial mineral sources with supplemental minerals primarily from a commercial Ca-Mg dolomite source; MIN-AD, Papillon Agricultural Company Inc., Easton, MD) beginning at 21 d before due date; cows were further randomized within source treatments to 1 of 2 levels of Mg supplementation (LM = formulated postpartum diet Mg at 0.30% of DM, or HM = formulated postpartum diet Mg at 0.45% of DM) beginning within 1 d after parturition. Final treatment groups included the following: common source, low Mg (CS-LM, n = 11); common source, high Mg (CS-HM, n = 11); MIN-AD, low Mg (MA-LM, n = 10); and MIN-AD, high Mg (MA-HM, n = 9). Treatment diets were fed and data collected through 42 d in milk. Postpartum plasma Mg concentrations tended to be higher for cows fed HM and cows fed CS, but no effects were observed on peripartum plasma Ca concentrations. Peripartum plasma P concentrations were higher for cows fed MA. Dry matter intake (DMI) in the prepartum period was higher for cows fed MA (CS = 15.9 vs. MA = 16.8 kg/d) and postpartum DMI was higher in some groups depending on week. Plasma nonesterified fatty acid concentrations were lower for cows fed MA during both the prepartum and postpartum periods. A source by level interaction was observed for postpartum plasma β-hydroxybutyrate (BHB) concentrations such that cows fed CS-LM had numerically higher BHB and cows fed MA-LM had numerically lower BHB (geometric means; CS-LM = 7.9, CS-HM = 6.9, MA-LM = 6.3, and MA-HM = 7.3 mg/dL) than cows fed the other 2 treatments. Higher milk fat yield, milk fat content, and fat- and energy-corrected yield during wk 1 for cows fed MA resulted in source by week interactions for these outcomes. This study demonstrated that varying supplemental Ca and Mg sources and feeding rates had minimal effect on plasma Ca status despite differences in plasma Mg and P concentrations. Effects on DMI and plasma energy metabolites suggest an opportunity for strategic use of mineral sources in the transition period to promote metabolic health.
Key words: transition cow, magnesium, calcium

INTRODUCTION

Hypocalcemia is a disorder in which blood Ca concentrations are compromised as the result of inadequate adaptation to the lactational demands for Ca that begin at the onset of colostrum production in dairy cows (Ramberg et al., 1970). Recent research has determined that 11 to 25% of first lactation animals and 42 to 60% of multiparous cows can be categorized as having subclinical hypocalcemia (**SCH**; low blood Ca with no clinical signs of hypocalcemia) in the day after parturition (Reinhardt et al., 2011; Caixeta et al., 2015). Martinez et al. (2012) demonstrated an association between SCH and compromised energy metabolism, risk of uterine disease, and delayed reproduction. Additional work described similar associations with reproduction (Chapinal et al., 2012) and energy metabolism (Chamberlin et al., 2013) and has further demonstrated increased risk for displaced abomasum and early lacta-

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tion culling (Chapinal et al., 2011; Roberts et al., 2012) as well as decreased early lactation milk production (Chapinal et al., 2012) in cows with SCH. Taken together, the body of evidence suggests that SCH is a highly prevalent and costly disorder.

Magnesium is known to be an important mineral in the homeostatic pathway for regulating blood Ca based on work conducted in cows (van Mosel et al., 1990, 1991) and humans (Rude et al., 1978, 1985). Feeding higher concentrations of dietary Mg prepartum (0.45–0.50% of DM) has become common practice to aid in prevention of hypocalcemia at parturition and was supported by a meta-analysis conducted by Lean et al. (2006). Decreased blood Mg concentrations during the week after parturition have been reported in several published studies (Green et al., 1981; Shappell et al., 1987; Ramos-Nieves et al., 2009; Kronqvist et al., 2011); however, little work has been done to understand the causes and consequences of this blood Mg pattern. Theoretically, feeding higher dietary rates of Mg postpartum to increase blood Mg may help in the recovery of plasma Ca because plasma Ca concentrations have been shown to take several days to return to prepartum levels (Ramos-Nieves et al., 2009). To the authors' knowledge, feeding varying rates of Mg postpartum to support the recovery of blood Ca has not been investigated.

Dietary mineral source may have effects on mineral status due to variation in bioavailability, which can be affected by calcination temperature, chemical structure, and particle size (Moore et al., 1971; Jesse et al., 1981; Van Ravenswaay et al., 1989; Xin et al., 1989). Further, mineral sources of different chemical structures have been shown to have varying buffering capacities (Schaefer et al., 1982), which may aid in transition period intake and performance where diet transitions have been shown to challenge rumen health (Penner et al., 2007). Investigation of the performance of cows in the transition period fed varying supplemental mineral sources may provide evidence for strategic use of mineral sources to promote successful diet transitions.

The objectives of this experiment were to determine the effects of dietary source of supplemental Ca and Mg, and postpartum dietary level of Mg, on intake, performance, and aspects of energy and mineral metabolism in multiparous Holstein cows. We hypothesized that plasma mineral status would be altered by feeding supplemental minerals from a commercial Ca-Mg dolomite and feeding a higher rate of dietary Mg postpartum. If plasma mineral status was improved by either factor, it was hypothesized that intake and performance would also be improved in those cows.

MATERIALS AND METHODS

Study Population, Experimental Design, and Treatments

All animal protocols were approved by the Cornell University Institutional Animal Care and Use Committee. Animals were enrolled in the experiment between May and July of 2015. Multiparous Holstein cows (n = 47) were enrolled in a completely randomized design with a 2 × 2 factorial arrangement of treatments starting at 28 d before expected parturition. Cows were fed a control diet for 1 wk, and at 21 d before expected parturition cows were assigned randomly to treatment with randomization restricted to balance for parity group (second vs. third and greater lactation) and previous 305-d mature equivalent milk production. During the prepartum period, cows were randomized to 1 of 2 source treatments in which supplemental dietary Ca and Mg were provided primarily from common sources [Mg oxide (BRAZAMAG, Timab Industries, Dinard, France) and limestone; **CS**] or from a blend of common and commercial mineral sources with supplemental minerals primarily from a commercial Ca-Mg dolomite source (MIN-AD, Papillon Agricultural Company, Easton, MD; **MA**). At the next feeding that occurred after parturition, both CS and MA groups were further randomized into 2 groups within their source treatments in which one received diets formulated to contain Mg at about NRC (2001) recommendations (**CS-LM** and **MA-LM** = 0.30% of DM) or at a higher rate (**CS-HM** and **MA-HM** = 0.45% of DM). Cows were fed experimental diets and data were collected through 42 DIM. The target study population was 40 cows total. Sample size determination was based on detecting biologically important differences in plasma mineral concentrations in the week following parturition. The average and standard deviations for these outcomes were based on previous work conducted in our group for a treatment group fed similar prepartum rations (Leno et al., 2017). With $\alpha = 0.05$ and $\beta = 0.20$, the detectable difference in wk 1 for Ca, Mg, and P for the main effects of source and level were 0.27, 0.11, and 0.30 mmol/L, respectively. Criteria for removal from the trial included twin births (n = 5) and calving with less than 10 d fed the experimental prepartum diet (n = 1). Cows excluded before the end of the enrollment period were replaced, and in anticipation of the loss of cows from the trial, one additional cow was enrolled into each treatment group at the end of the enrollment period. The final data set included 41 cows from which 11 were in the common source, low Mg group (CS-LM); 11 were in the common source, high Mg group (CS-HM); 10 were in