EFFECT OF PERIPARTUM SOURCE OF MAGNESIUM AND CALCIUM, AND POSTPARTUM FEEDING RATE OF MAGNESIUM, ON INTAKE, PERFORMANCE AND MINERAL AND ENERGY STATUS OF MULTIPAROUS HOLSTEIN COWS

B. M. Leno[1], S. E. Williams[1], C. M. Ryan[1], D. Briggs[2], M. Crombie[3], T. R. Overton[1]
[1]Department of Animal Science, Cornell University
[2]Papillon Agricultural Company, Inc., Easton, MD
[3]MIN-AD, Inc., Winnemucca, NV

INTRODUCTION

Subclinical hypocalcemia (**SCH**) is disorder in which blood Ca concentrations fall below a critical threshold as the result of inadequate adaptation to the lactational demands for Ca that occur at the onset of colostrum production in dairy cows (Ramberg et al., 1970). Recent research has determined that 11-25% of first lactation animals and 42-60% of multiparous cows can be categorized as subclinically hypocalcemic in the day after parturition (Reinhardt et al., 2011; Caixeta et al., 2015). This is likely a conservative estimate of the true prevalence of SCH after parturition as we continue to learn more about the associations between the severity and duration of low blood Ca after parturition and negative downstream consequences. Martinez et al. (2012) demonstrated a strong association between SCH and compromised energy metabolism, risk of uterine disease and delayed reproduction. Additional work has found 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 lactation 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 from work conducted in cows (van Mosel et al., 1990; van Mosel et al., 1991) and humans (Rude et al., 1978; Rude et al., 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 has been supported in a meta-analysis by Lean et al. (2006). Postpartum plasma Ca concentrations have been shown to take several days to return to prepartum levels (Ramos-Nieves et al., 2009) and theoretically, feeding higher concentrations of Mg postpartum may help in the recovery of plasma Ca. To the author's knowledge, feeding varying rates of Mg postpartum to support the recovery of blood Ca has not been investigated.

Mineral status in the transition period may vary based on supplemental mineral source due to differences in bioavailability. Bioavailability can be affected by chemical structure, particle size or both (Moore et al., 1971; 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 intake and performance during the transition period where diet transitions have been shown to challenge rumen health

(Penner et al., 2007). Investigation of 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 and optimal mineral status.

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.

EXPERIMENTAL APPROACH

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 2 × 2 factorial design experiment starting at 28 d prior to expected parturition. Cows were fed a control diet for one week and at 21 d prior to expected parturition cows were randomly assigned to treatment with randomization restricted to balance for parity group (2nd vs. 3rd and greater lactation) and previous lactation 305 d mature equivalent milk production. Prepartum, cows were randomized to one of two source treatments in which supplemental dietary Ca and Mg were provided primarily from common sources (Mg oxide and limestone; **CS**) or a commercial Ca-Mg dolomite supplemental mineral source (MIN-AD, Papillon Agricultural Company, Easton, MD; **MA**). At the next feeding that occurred after calving, cows were further randomized to receive diets formulated to contain Mg at close to NRC (2001) recommendations or at a higher rate (**LM** = 0.30% of DM, **HM** = 0.45% of DM) within their source treatments. Cows were followed through 42 DIM. Criteria for removal from the trial included twin calving and calving with less than 10 d on the experimental prepartum diet. 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 dataset 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 the MIN-AD, low Mg group (**MA-LM**) and 9 were in the MIN-AD, high Mg group (**MA-HM**).

Cows were housed in tiestalls and fed once daily at approximately 0800 h for lactating cows and 0930 for dry cows. Individual feed intake was measured on a daily basis throughout the experiment by weighing feed delivered and refused. Cows were fed for a targeted refusal rate of 10% to allow for ad libitum intake. Rations were formulated using the Cornell Net Carbohydrate and Protein System (CNCPS v. 6.5). Ingredient composition and analyzed diet composition of all prepartum and postpartum treatment diets are presented in Tables 1 and 2. All rations were composed of a base TMR containing forages and a base grain mix as well as a small inclusion rate grain mix (containing supplemental minerals). The base TMR was mixed in one batch for all prepartum cows and in one batch for all postpartum cows. Prior to delivery to the cow,

smaller batches were made which included the small inclusion rate grain mixes. Samples of TMR and all feed ingredients were collected weekly for determination of DM (dried at 40°C for 96 h). Weekly dry matters were used to adjust as fed inclusion rates of all forages and grain ingredients and to calculate DMI. At the end of the experiment, dried samples were ground to 2 mm in a Wiley mill and composited at 4 wk intervals for TMR samples and over the duration of the trial for all forages and grains. Composited samples were sent to a commercial laboratory (Cumberland Valley Analytical Services, Hagerstown, MD) for wet chemistry analysis.

Cows were observed daily throughout the experiment for health disorders. Body weights were measured weekly and BCS assigned by two scorers weekly according to Edmonson et al. (1989) beginning during the week prior to assignment to treatment and continuing through 42 d postpartum. Body condition scores were averaged over two scorers before statistical analysis.

After calving, all cows were milked three times daily at 0600 h, 1400 h and 2200 h and milk weights recorded. Milk samples were collected at 3 consecutive milkings each week and analyzed at a commercial laboratory (DairyOne, Ithaca, NY) for milk fat, protein, lactose, total solids and MUN using mid-infrared techniques (Method 972.16, (AOAC International, 2006) and SCC was determined by optical fluorescence (Method 978.26, (AOAC International, 2006). Somatic cell scores were calculated from SCC (SCS = $\log_2$(SCC/100,000)+3). Milk yield at the corresponding milking was used to weight milk composition and calculate yield of fat, protein, lactose and total solids. Weekly average yield of 3.5% FCM was calculated [3.5% FCM = (0.432 × kg of wk average milk yield) + (16.216 × kg of fat)] as well as weekly average yield of ECM [ECM = (0.327 × kg of wk average milk yield) + (12.95 × kg of fat) + (7.65 × kg of true protein)]. Milk production efficiency was calculated from weekly average DMI and ECM (efficiency = kg of ECM/ kg of DMI). Weekly energy balance (**EBAL**) was calculated according to NRC (2001).

Blood samples were collected via coccygeal venipuncture between 0600 h and 0730 h 2×/wk from d -28 relative to expected parturition until parturition (Monday and Friday), within 2 h of parturition (d 0), daily from d 1 through 7 in milk, and 3×/wk thereafter (Monday, Wednesday and Friday) through 21 DIM. Plasma was harvested and snap frozen in liquid nitrogen and stored at -20°C until analysis. A subset of samples were analyzed using commercial enzymatic kits for β-hydroxybutyrate (**BHBA;** Catachem Inc., Oxford, CT) and non-esterified fatty acids (**NEFA;** HR Series NEFA HR (2), Wako Pure Chemical Industries, Osaka, Japan). Mineral concentrations were determined at the Cornell Animal Health and Diagnostic Center (Ithaca, NY) on an automated analyzer (Hitachi Modular P800, Roche Diagnostics, Indianapolis, IN).

STATISTICAL ANALYSIS

Prepartum and postpartum data were analyzed separately. All statistical analyses were conducted with the statistical software SAS (version 9.4, SAS Institute Inc., Cary, NC). All measurements repeated over time were subjected to repeated measures analysis using the REPEATED statement in the MIXED procedure of SAS (Littell et al.,

1996). The fixed effects of time, source, level (postpartum only), parity group (2nd vs. 3rd+ lactation) and the two- and three-way interactions of source, level (postpartum only) and time were included in the model.

Table 1. Ingredient composition of prepartum and postpartum diets

	Prepartum Diet[1]		Postpartum Diet[1]			
Ingredient (% of DM)	CS	MA	CS-LM	CS-HM	MA-LM	MA-HM
Brown mid-rib corn silage	37.59	37.59	38.00	38.00	38.00	38.00
Alfalfa hay	-	-	7.60	7.60	7.60	7.60
Wheat straw	23.23	23.23	6.21	6.21	6.21	6.21
Corn grain, finely ground	2.29	2.29	17.10	17.10	17.10	17.10
Wheat midds	6.54	6.54	4.71	4.71	4.71	4.71
Citrus pulp	4.31	4.31	4.75	4.75	4.75	4.75
Soybean hulls	6.50	6.50	2.13	2.13	2.13	2.13
Canola meal	3.33	3.33	3.80	3.80	3.80	3.80
Corn gluten feed	1.67	1.67	2.37	2.37	2.37	2.37
Distillers	1.09	0.62	1.29	1.02	1.13	0.58
Amino Plus[2]	2.32	2.32	5.70	5.70	5.70	5.70
Gemini Protein[3]	1.99	1.99	2.28	2.28	2.28	2.28
Energy Booster 100[4]	-	-	1.14	1.14	1.14	1.14
Biochlor[5]	5.56	5.56	-	-	-	-
Alimet[6]	0.07	0.07	0.06	0.06	0.06	0.06
Salt	0.33	0.33	0.57	0.57	0.57	0.57
Sodium bicarbonate	-	-	0.38	0.38	0.38	0.38
Limestone	2.46	1.49	1.35	1.38	1.08	0.47
Ca sulfate	-	-	0.25	0.25	0.25	0.25
Mg oxide	0.41	0.09	0.13	0.38	0.05	0.08
MIN-AD[7]	-	1.78	-	-	0.52	1.66
Mineral oil	0.02	0.02	0.02	0.02	0.02	0.02
Rumensin[8]	0.04	0.04	0.06	0.06	0.06	0.06
Trace minerals & vitamins	0.21	0.21	0.04	0.04	0.04	0.04

[1]Treatments consist of a 2 × 2 factorial arrangement of source assignments (CS = common sources of supplemental minerals, MA = supplemental minerals from a commercial source) beginning at 21 d prior to due date, and level assignments (LM = formulated diet Mg at 0.30% of DM, HM = formulated diet Mg at 0.45% of DM) beginning within 1 d after parturition. Treatments were continued through 42 DIM.
[2]Ag Processing, Inc. Omaha, NE
[3]Papillon Agricultural Company, Inc., Easton, MD
[4]Milk Specialties Global, Eden Prairie, MN
[5]Church & Dwight Co., Inc., Trenton, NJ
[6]Novus International, Saint Charles, MO
[7]Papillon Agricultural Company, Easton, MD
[8]Elanco Animal Health, Greenfield, IN. Contained 26,400 g/ton monensin.

Table 2. Analyzed nutrient composition and partitioning of mineral intake by sources

	Prepartum Diet[1]		Postpartum Diet[1]			
	CS	MA	CS-LM	CS-HM	MA-LM	MA-HM
Nutrient (mean ± SD)						
DM (%)	45.7 ± 2.0	46.4 ± 1.6	45.8 ± 1.0	46.0 ± 1.2	45.5 ± 1.0	45.5 ± 1.2
CP (% of DM)	14.3 ± 0.4	14.1 ± 0.6	14.9 ± 0.2	15.0 ± 0.26	15.2 ± 0.38	15.4 ± 0.4
ADF (% of DM)	28.1 ± 0.9	29.5 ± 0.6	20.9 ± 0.2	21.5 ± 0.6	21.2 ± 1.0	21.1 ± 0.5
NDF (% of DM)	43.4 ± 0.8	45.4 ± 0.9	32.5 ± 0.2	32.9 ± 0.3	33.2 ± 0.9	33.4 ± 0.9
Lignin (% of DM)	3.9 ± 0.2	4.1 ± 0.2	2.1 ± 1.2	3.3 ± 0.1	3.2 ± 0.1	3.1 ± 0.1
Starch (% of DM)	15.8 ± 0.8	14.5 ± 1.5	25.5 ± 0.9	25.3 ± 0.6	24.6 ± 0.4	25.2 ± 0.4
NFC (% of DM)	33.0 ± 1.2	31.2 ± 0.9	45.2 ± 0.7	43.7 ± 0.29	43.5 ± 1.3	43.6 ± 1.2
Fat (% of DM)	2.17 ± 0.08	2.22 ± 0.15	3.25 ± 0.26	3.10 ± 0.09	3.04 ± 0.13	2.87 ± 0.24
Ca (% of DM)	1.44 ± 0.00	1.40 ± 0.00	1.21 ± 0.08	1.13 ± 0.06	1.17 ± 0.07	1.24 ± 0.03
P (% of DM)	0.35 ± 0.00	0.34 ± 0.00	0.36 ± 0.01	0.34 ± 0.01	0.37 ± 0.01	0.36 ± 0.00
Mg (% of DM)	0.49 ± 0.02	0.52 ± 0.01	0.35 ± 0.02	0.40 ± 0.01	0.35 ± 0.01	0.48 ± 0.00
K (% of DM)	1.08 ± 0.02	1.08 ± 0.03	1.00 ± 0.03	0.98 ± 0.03	1.02 ± 0.03	1.01 ± 0.04
S (% of DM)	0.45 ± 0.01	0.44 ± 0.01	0.32 ± 0.01	0.33 ± 0.02	0.33 ± 0.02	0.33 ± 0.02
Na (% of DM)	0.26 ± 0.01	0.25 ± 0.02	0.42 ± 0.01	0.42 ± 0.00	0.43 ± 0.01	0.43 ± 0.01
Cl (% of DM)	0.79 ± 0.04	0.80 ± 0.05	0.53 ± 0.01	0.53 ± 0.02	0.54 ± 0.01	0.53 ± 0.02
DCAD (mEq/100 g DM)	-11.2 ± 1.0	-11.1 ± 1.4	8.7 ± 1.1	7.7 ± 1.2	8.9 ± 1.7	9.2 ± 1.9
NE_L (Mcal/kg)	1.46 ± 0.02	1.43 ± 0.02	1.65 ± 0.09	1.61 ± 0.02	1.61 ± 0.02	1.61 ± 0.02
MP (g/kg DM)[2]	91.1	90.8	113.9	113.8	113.6	113.4
MP Intake (g/d)[3]	1549	1616	2312	2390	2295	2427
Mineral Intake Sources[3]						
Mg from MIN-AD (g/d)	-	36.6	-	-	12.1	40.9
Mg from Mg Oxide (g/d)	37.8	8.5	15.4	43.6	5.0	9.5
Mg from Other (g/d)	45.5	48.0	55.6	40.4	53.6	52.3
Ca from MIN-AD (g/d)	-	68.4	-	-	22.6	76.4
Ca from Limestone (g/d)	159.1	101.2	104.1	110.5	82.9	38.5
Ca from Other (g/d)	85.8	81.1	141.6	126.8	130.9	150.5

[1]Treatments consist of a 2 × 2 factorial arrangement of source assignments (CS = common sources of supplemental minerals, MA = supplemental minerals from a commercial source) beginning at 21 d prior to due date, and level assignments (LM = formulated diet Mg at 0.30% of DM, HM = formulated diet Mg at 0.45% of DM) beginning within 1 d after parturition. Treatments were continued through 42 DIM.
[2]Metabolizable protein (**MP**) intake as predicted by CNCPS (v. 6.5) based on forage composite analyzed composition
[3]Based on actual 21 d prepartum and postpartum intake, predicted diet MP supply and analyzed mineral concentrations

Cow within source (prepartum) or source and level (postpartum) was the random effect. When available, covariate measurements collected in the week prior to treatment assignment were included in all models. Previous lactation 305 d mature equivalent milk production was included as a covariate for milk yield. The Kenward Rogers method was used for estimation of denominator degrees of freedom. Four covariance structures were tested for each model and the model with the lowest Aikaike's Information Criterion was selected. When $P \leq 0.10$ for interactions with time, the SLICE option was used in the LSMEANS statement to conduct an F-test to determine at which levels of time the treatment groups differed. When non-normality of residual variance was evident (NEFA and postpartum BHBA), data were log transformed and analysis repeated. Least squares means and standard errors, or geometric mean and confidence intervals (NEFA and postpartum BHBA), are reported throughout. Significance was declared at $P \leq 0.05$ and trends are discussed at $0.05 < P \leq 0.10$.

RESULTS

Analyzed dietary Mg concentration of postpartum treatment diets were different from formulated (Table 2). Both of the LM diets had analyzed Mg concentrations of 0.35% of DM, above the targeted 0.30% of DM. The concentration of Mg in the HM diets was higher than the LM diets, however, they were different from one another with the CS-HM diet at 0.40% of DM and the MA-HM diet at 0.48% of DM. Intake of Mg and Ca from supplemental sources versus basal ingredients is also presented in Table 2. Overall, differences in level of Mg were apparent, justifying analysis of data for any effects of level. As will be discussed, level effects were minimal and this may have been due at least in part to the variation in actual diet Mg concentrations versus the formulated composition. The population of cows in this trial was exceptionally healthy presenting a challenging test of the source and level treatments. Incidence of retained placenta and displaced abomasum were both 2% (n = 1/41), incidence of metritis was 17% (n = 7/41) and only 2 cows had at least one case of clinical mastitis during the study period (5%).

Prepartum DMI was affected by supplemental mineral source and cows fed supplemental minerals primarily from MIN-AD had higher DMI (CS = 17.0 vs. MA = 17.8 kg/d, $P = 0.05$, Figure 1). Similarly, DMI as a percent of BW was higher in cows fed MA (CS = 2.13 vs. MA = 2.23% of BW, $P = 0.05$). An interaction of source, level and time was observed for postpartum DMI ($P = 0.01$; Figure 1) and DMI as a percent of BW ($P = 0.05$) and DMI appeared to be higher for cows fed MA-HM in wk 2 postpartum and for cows fed CS-HM in wk 4, however, none of the slice effects at particular weeks were significant. Previous work suggests that chemical composition and quality of processing of Mg sources can impact buffering capacity (Schaefer et al., 1982). While the buffering capacity of the mineral sources was not tested in this trial, it is possible that a higher buffering capacity of MIN-AD contributed to differences in DMI. While this is plausible postpartum as cows transition onto higher starch postpartum diets, it is unlikely during the prepartum period when cows are consuming low starch, high fiber diets. A previous trial demonstrated that cows fed dolomitic minerals had decreased fiber digestions and increased passage rate (Moore et al., 1971), which may be another potential mechanism for higher intake in cows fed MA.

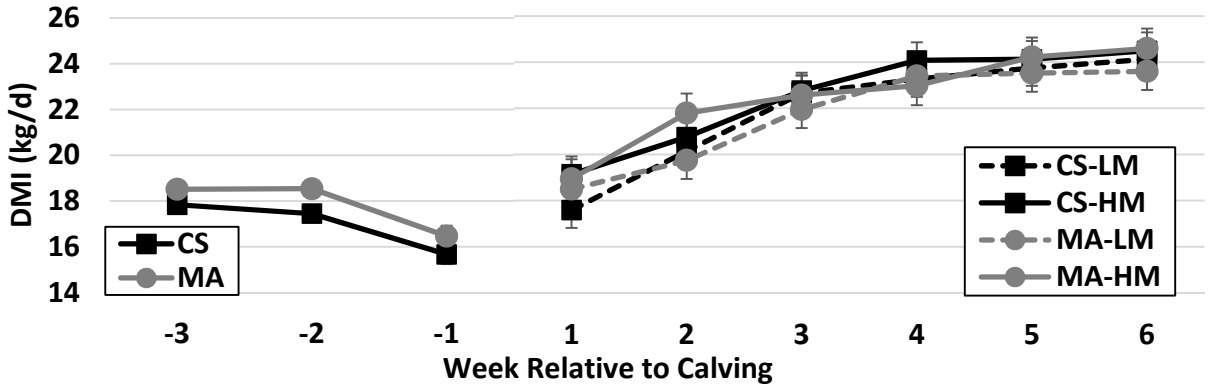

Figure 1. Least squares means and standard errors for DMI in the 3 wk prepartum period and from wk 1 through 6 postpartum

Calculated EBAL was similarly affected prepartum by supplemental mineral source and EBAL tended to be higher for cows fed MA (CS = 8.8 vs. MA = 10.0 Mcal/d, $P = 0.06$). There were no significant effects on EBAL postpartum. Prepartum and postpartum plasma concentrations of NEFA and BHBA are presented in Figure 2. As expected based on the effects on DMI, plasma concentrations of NEFA prepartum were lower in cows fed MA ($P = 0.004$). Cows fed MA also tended to have lower NEFA in the postpartum period ($P = 0.09$). There were no effects of treatment on prepartum plasma concentrations of BHBA but there was a trend for an interaction of source and level on postpartum plasma BHBA concentrations ($P = 0.09$) and BHBA concentrations were numerically lowest in cows fed MA-LM but multiple comparisons using Tukey's adjustment did not reveal differences between specific groups.

Results for milk yield, milk composition and milk production efficiency are presented in Table 3. There were no effects of source or level on milk yield, protein content, protein yield, lactose content, lactose yield, total solids content, milk production efficiency or somatic cell score. An interesting source by week effect was found for fat content ($P = 0.07$), fat yield ($P = 0.02$), fat-corrected yield ($P = 0.04$), total solids yield ($P = 0.05$) and energy-corrected yield ($P = 0.03$). These effects are driven by higher content and yield of fat in wk 1 for cows fed MA ($P < 0.05$). Considering the trend for lower plasma NEFA concentrations in the first 21 d postpartum for cows fed MA, it is hypothesized that the additional source of milk fat is not from the mobilization of body reserves as is typically expected when fat content is higher immediately after parturition. The DIM at which the first week's milk sampling occurred tended to be lower for cows fed CS compared to cows fed MA (CS = 3.3 vs. MA = 4.3 DIM; $P = 0.09$), suggesting that higher fat content due to colostrum composition is not responsible for this source effect. Controlling for the random effect of DIM within sampling week did not alter interpretation of the data and therefore was not included in the final analysis.

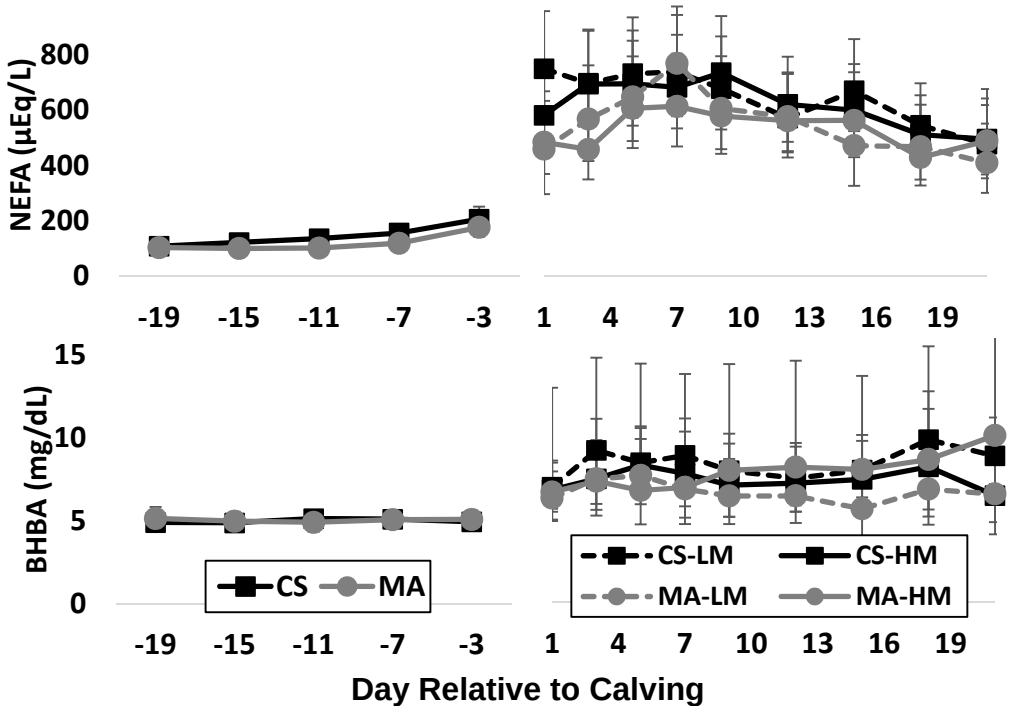

Figure 2. Geometric means and back transformed 95% confidence limits, or least squares means and 95% confidence intervals (prepartum BHBA), for NEFA and BHBA for the 3 wk prepartum and postpartum

Postpartum plasma mineral concentrations over time are presented in Figure 4. There were no overall effects of dietary supplemental mineral source on prepartum plasma concentrations of Ca (CS = 2.44 vs. MA = 2.44 mmol/L; *P* = 0.85) or Mg (CS = 0.96 vs. MA = 0.96 mmol/L; *P* = 0.59), although cows fed MA had higher concentrations of P in plasma prepartum (CS = 1.69 vs. MA = 1.79 mmol/L; *P* = 0.02). Postpartum plasma P tended to be higher for cows fed MA (*P* = 0.09), consistent with the effects in the prepartum period. Higher plasma P concentrations have been demonstrated when intake of P is increased (Barton et al., 1987) and higher intake for cows fed MA may be responsible for higher plasma P concentrations. Postpartum plasma Mg tended to be lower for cows fed LM compared to cows fed HM (*P* = 0.11) which would be expected in diets with lower Mg supply (van Mosel et al., 1991). Postpartum plasma Mg also tended to be lower for cows fed MA compared to cows fed CS (*P* = 0.10). Some work has demonstrated competitive inhibition of Mg absorption as dietary concentration, or ruminal concentration, of Ca increased (Care et al., 1984; Kronqvist et al., 2011). If ruminal concentration of Ca was higher in cows fed MA due to higher intake of Ca, or greater solubility of that Ca, this could have contributed to lower plasma Mg postpartum in cows fed MA. There is evidence from work in steers suggesting that apparent Mg absorption from Ca-Mg dolomites is lower than that of Mg oxide (Moore et al., 1971) and lower absorption coefficients are assigned to Ca-Mg dolomites by the NRC (2001). However, minimal work has been done assessing bioavailability of Mg sources in lactating dairy cows, especially that comparing different sources, particle sizes and rumen conditions. There were no effects of source or level on postpartum plasma Ca concentrations despite alterations in plasma Mg. Incidence of hypocalcemia (plasma Ca < 2.125 mmol/L) was

low in this trial. Peak prevalence of hypocalcemia was 51% at 1 DIM and was reduced to 27% at 2 DIM, 7% at 3 DIM and by 4 DIM no cows had plasma Ca < 2.125 mmol/L.

Table 3. Least squares means and standard error for milk yield, milk composition, and milk production efficiency over the first 6 wk postpartum

	Treatments[1]					*P*-values[2]					
Variable	CS-LM	CS-HM	MA-LM	MA-HM	SEM	S	L	S×T	L×T	S×L	S×L×T
Milk yield (kg/d)	45.0	46.5	45.9	44.0	1.8	0.64	0.89	0.19	0.47	0.30	0.54
Fat (%)	3.85	3.72	3.84	3.94	0.11	0.35	0.90	0.07	0.01	0.34	0.84
Fat (kg/d)	1.68	1.68	1.75	1.72	0.09	0.51	0.81	0.02	0.44	0.88	0.82
3.5% FCM (kg/d)	46.9	47.5	48.4	46.7	2.0	0.85	0.77	0.04	0.27	0.54	0.73
Protein (%)	2.86	2.81	2.83	2.87	0.07	0.78	0.90	0.64	0.50	0.49	0.55
Protein (kg/d)	1.24	1.24	1.29	1.23	0.05	0.67	0.49	0.18	0.41	0.55	0.24
Lactose (%)	4.86	4.84	4.81	4.87	0.05	0.85	0.72	0.29	0.97	0.50	0.97
Lactose (kg/d)	2.18	2.23	2.24	2.14	0.10	0.86	0.76	0.26	0.90	0.44	0.66
Total solids (%)	12.5	12.3	12.4	12.6	0.2	0.51	0.94	0.38	0.32	0.36	0.77
Total solids (kg/d)	5.53	5.56	5.72	5.50	0.25	0.78	0.69	0.05	0.68	0.61	0.51
ECM (kg/d)	46.1	46.5	47.6	45.9	1.9	0.80	0.70	0.03	0.50	0.54	0.58
ECM/DMI	2.12	2.09	2.17	2.03	0.07	0.91	0.21	0.28	0.84	0.43	0.46
MUN (mg/dL)	6.74	6.58	7.30	6.61	0.35	0.37	0.20	0.74	0.06	0.43	0.47

[1]Treatments consist of a 2 × 2 factorial arrangement of source assignments (C = common sources of supplemental minerals, M = supplemental minerals from a commercial source) beginning at 21 d prior to due date and level assignments (LM = formulated diet Mg at 0.30% of DM, HM = formulated diet Mg at 0.45% of DM) beginning within 1 d after parturition. Treatments were continued through 42 DIM.
[2]S = source; L = level; T = time

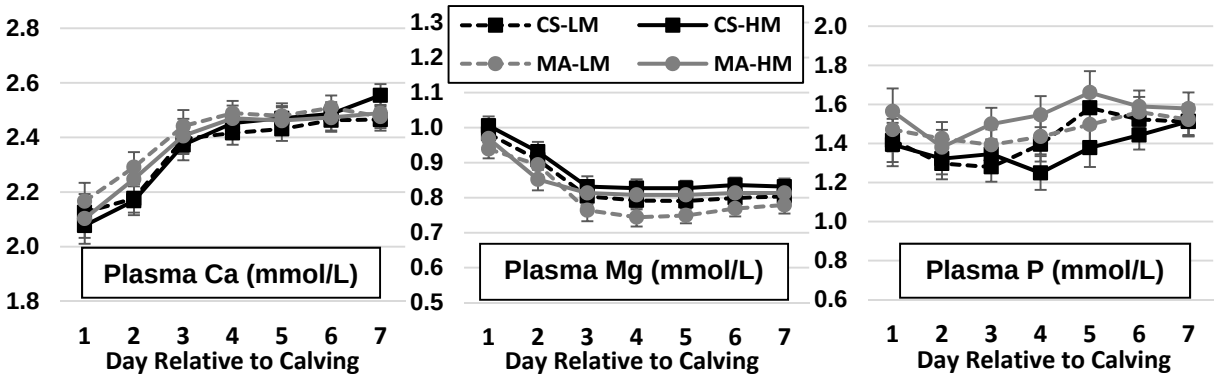

Figure 4. Least squares means and standard errors for plasma Ca, Mg and P from d 1 through 7 postpartum

CONCLUSIONS AND IMPLICATIONS

This experiment found that cows fed supplemental minerals from a commercial Ca-Mg dolomite source, compared to commonly used Mg oxide and limestone, had higher intakes in the prepartum period leading to lower concentrations of NEFA in plasma prepartum. Lower NEFA concentrations for cows fed MA tended to carry over into the postpartum period. The data also indicate potential intake advantages for cows fed MA in portions of the postpartum period. Results from this experiment suggest that there is opportunity for strategic use of mineral sources to aid in DMI and energy metabolism during the transition period.

Effects of dietary Mg level were minimal despite a tendency for cows fed LM to have lower plasma Mg concentrations. Neither dietary mineral source, nor level of Mg, influenced plasma Ca concentrations in the peripartum period. This suggests that in this study, feeding 0.35% of DM as Mg using either source was sufficient to support plasma Ca, resulting in low prevalence of hypocalcemia and a rapid recovery of blood Ca. This population of cows was exceptionally healthy and similar work in a study population with more severe mineral homeostasis challenges at parturition is warranted.

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