Effect of peripartum source of magnesium and calcium, and postpartum level of magnesium, on intake performance and mineral and energy status of multiparous Holstein cows

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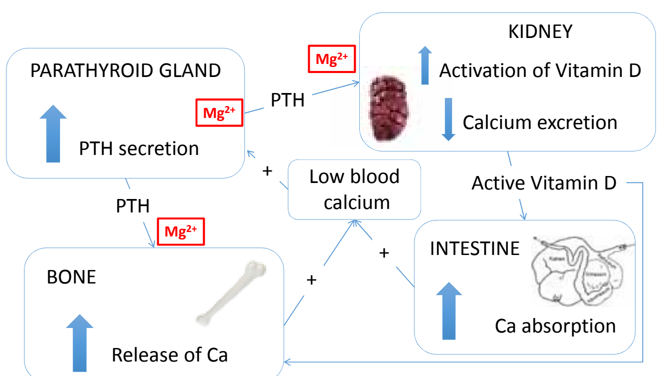
Hypocalcemia & Nutritional Strategies for Prevention

- Hypocalcemia is highly prevalent and impactful
  - 50% or more of multiparous cows are hypocalcemic postpartum (Reinhardt et al., 2011; Caixeta et al., 2015)
  - Hypocalcemia is associate with compromised health, performance and reproduction (Martinez et al., 2012; Chapinal et al., 2012; Chamberlin et al., 2013)
- Nutritional strategies for preventing hypocalcemia focus on:
  - Prepartum negative dietary cation-anion difference
  - Prepartum restricted Ca feeding
  - Prepartum Mg feeding rate
- Opportunity exists to further optimize mineral feeding **SOURCE** and dietary **LEVELS** to optimize mineral status

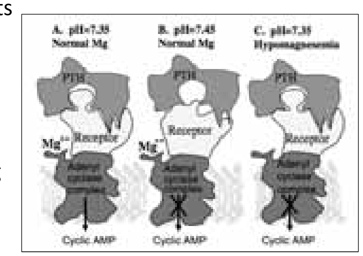
Acclimation to increased Ca demand may be aided through improved Mg status



Goff et al., 2008

Prepartum Mg status impacts hypocalcemia risk

- Mg status has been shown to affect aspects of Ca homeostasis in multiple species
  - PTH secretion & signaling
  - Production of 1,25-dihydroxyvitamin D
  - Bone mobilization
- Meta-analysis results show that increasing prepartum dietary Mg decreases clinical hypocalcemia risk in dairy cows
  - Feeding rates are typically 0.40-0.50% of DM

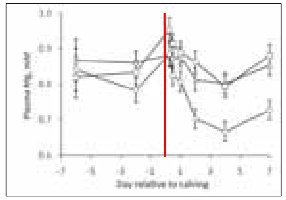


Goff et al., 2008

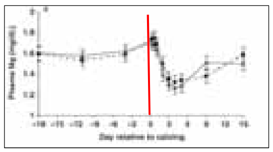
Rude et al., 1978; Forbes et al., 1980; Rude et al., 1985; van Mosel et al., 1991, Lean et al., 2009

Some degree of hypomagnesemia occurs in the week after parturition

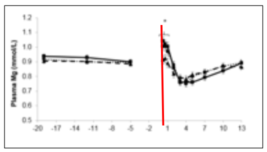
- Can this be impacted by increasing Mg supply?
  1. Feeding more bioavailable sources
  2. Feeding higher Mg concentration postpartum
- Does this result in a meaningful influence on Ca status?



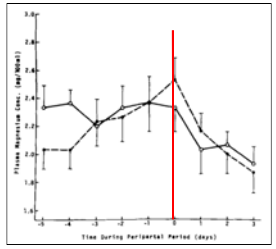
Kronqvist et al., 2011. J. Dairy Sci. 94:1365-1373



Ramos-Nieves et al., 2009. J. Dairy Sci. 92:5677-5691



Sweeney et al., 2015. J. Dairy Sci. 98 (Suppl. 2):128



Green et al., 1981. J. Dairy Sci. 64:217-226

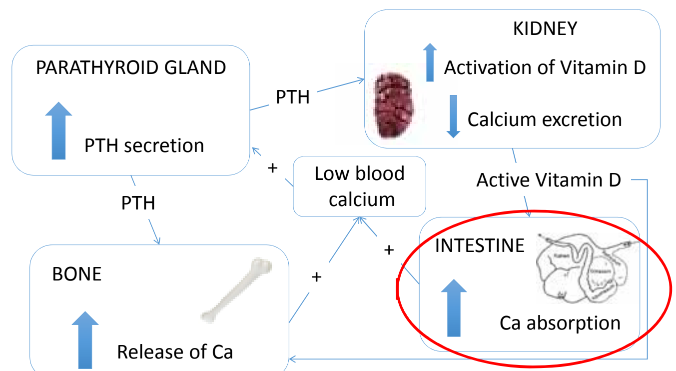
Current postpartum mineral feeding rate recommendations

- Mg
  - NRC 2001 example fresh cow ration = 0.29% of DM
  - No controlled trials looking at effect of Mg feeding level postpartum and blood mineral status
- Ca
  - NRC 2001 example fresh cow ration = 0.79% of DM
  - Taylor et al. (2009) found no difference in serum Ca when feeding Ca at 0.52, 0.78 or 1.03% of DM postpartum

Factors Affecting Mg Source Bioavailability

Factor	Mechanism	Evidence
Dietary [K]	Increased dietary [K] can impair Na-linked active transport	Jittakhot et al., 2004. J. Dairy Sci. 87:379-385 Ram et al., 1998. J Dairy Sci. 81:2485-2492 Weiss et al., 2004. J. Dairy Sci. 87:2167-2171
Particle size/solubility	Smaller particle size is associated with greater solubility and bioavailability and contributes to greater passive absorption	Xin et al., 1989. J. Dairy Sci. 72:462-470 Van Ravenswaay et al., 1989. J. Dairy Sci. 72:2968-2980
Chemical form	Evidence supports greater bioavailability in highly soluble source Mg oxide with lower bioavailability in Mg carbonate and dolomite sources but data are limited	Rahnema et al., 1983. J. Anim. Sci. 57:1545-1552 Ammerman et al., 1972. J. Anim. Sci. 34:122-126 Gerken et al., 1967. J. Anim. Sci. 26:1404-1408 Moore et al., 1971. J. Anim. Sci. 33:502-506
Ca/Mg absorption antagonism	Some evidence suggest antagonistic relationships between absorption when dietary/ruminal concentrations of Ca are high	Care et al., 1984. J. Exp. Phys. 69:577-587 Kronqvist et al., 2011. J. Dairy Sci. 94:1365-1373

Ca absorption is highly regulated, increased supply does not directly improve status



Goff et al., 2008

How does supplementation with a commercial Ca-Mg dolomite compare to feeding supplemental Ca and Mg from common sources?

Feeding dolomite sources has been minimally investigated in recent years with very little work in dairy cows

Ca-Mg dolomite – MIN-AD (Papillon Agricultural Company, Inc., Easton, MD)
- 21% of DM as Ca
- 12% of DM as Mg

Common sources – Limestone & Mg oxide
- Limestone Ca carbonate – 38% Ca
- Mg Oxide – 54% Mg

Mg Oxide Particle Size Description:

PARAMETERS	TYPICAL
> 0.850 mm (20 mesh)	0.80%
> 0.500 mm (32 mesh)	27.44%
> 0.300 mm (48 mesh)	71.19%
> 0.150 mm (100 mesh)	89.95%

Mineral sources have varying buffering capacities

- Transition onto higher starch fresh cow rations can challenge rumen health and increase risk for subacute rumen acidosis
- Potential exists to strategically use mineral sources that provide additional buffering in the transition period
- Buffering capacity can vary between and within mineral sources

Penner et al., 2007; Xin et al., 1989

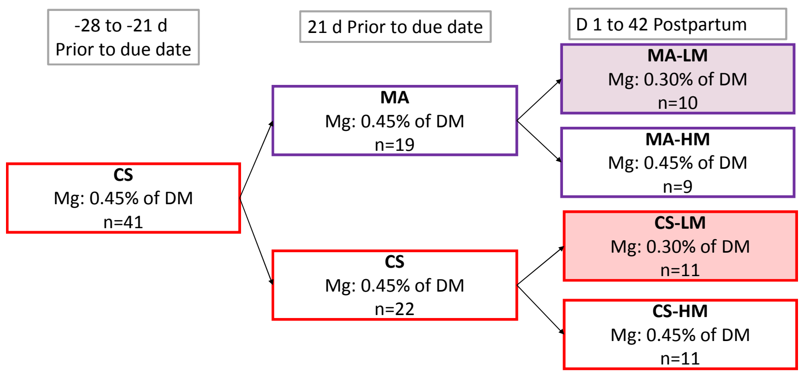
Objectives

- Determine the effect of varying supplemental mineral sources in the peripartum period
  - Common sources (**CS**) - Mg oxide and limestone
  - Ca-Mg dolomite source (**MA**) – MIN-AD
- Determine the effect of feeding Mg at different levels postpartum
  - Low Mg (**LM**) – 0.30% of DM
  - High Mg (**HM**) – 0.45% of DM
- Outcomes of interest:
  - Peripartum plasma mineral status
  - DMI and performance
  - Plasma energy metabolites

Materials and Methods

- 47 Multiparous cows randomly assigned to treatments in a 2×2 factorial design
  - Randomization restricted to balance for parity and previous 305ME milk production
  - Exclusion criteria = calving >11 d prior to due date, calving with twins
- Feed offered and refused recorded daily
  - Fed for a targeted 10% refusals to allow ad libitum intake
  - Feed & TMR samples collected weekly, composited over 4 weeks for wet chemistry analysis (Cumberland Valley Analytical Services, Hagerstown, MD)
- Milk production
  - Yield measured daily and averaged by week postpartum
  - Milk composition analyzed at all milkings on one day per week (DairyOne, Ithaca, NY)
- Blood sampling
  - 2×/wk beginning in covariate week until parturition, within 2 h of calving, daily from 1 to 7 DIM and 3x/wk through 21 DIM
  - Subsets of plasma samples analyzed for Ca, Mg, P, NEFA and BHBA

Experimental Design: 2×2 Factorial



CS = Common Sources **MA** = MIN-AD **LM** = Low Mg **HM** = High Mg

Statistical Analysis

- Prepartum and postpartum data were analyzed separately
- Statistical analysis was conducted using the statistical software SAS (version 9.4, SAS Institute, Cary, NC)
  - Repeated measures data analyzed using PROC MIXED
  - The REPEATED statement was used to control for the random effect of cow within source (prepartum) or source and level (postpartum) over time
- Model variables included:
  - Parity (2^{nd} lactation vs. 3^{rd} and greater)
  - Source (CS vs. MA)
  - Level (LM vs. HM) - postpartum
  - Time (day or week)
  - Two- and three- way interactions of source, level and time when applicable
  - Covariates measures when available

Prepartum Rations: Ingredient Composition (% DM)

Nutrient	CS	MA
BMR CS	37.6	37.6
Wheat Straw	23.2	23.2
Wheat midds	6.54	6.54
Soybean hulls	6.50	6.50
Biochlor	5.56	5.56
Citrus pulp	4.31	4.31
Canola meal	3.33	3.33
Amino Plus	2.32	2.32
Corn grain	2.29	2.29
Gemini Protein	1.99	1.99
Corn gluten feed	1.67	1.67
Calcium carbonate	0.98	0.98
Salt	0.33	0.33
Vitamin E	0.16	0.16
Alimet	0.07	0.07
Rumensin	0.04	0.04
Calcium carbonate	1.48	0.51
Distillers	1.10	0.62
Magnesium oxide	0.41	0.09
MIN-AD	-	1.78
Mineral Oil	0.02	0.02
Trace minerals	0.04	0.04

Prepartum Rations: Analyzed Composition (Mean ± S.D.)

Nutrient	CS	MA
DM (%)	43.0 ± 1.8	43.8 ± 1.4
CP (% DM)	14.3 ± 0.4	14.1 ± 0.6
ADF (% DM)	28.1 ± 0.9	29.5 ± 0.6
NDF (% DM)	43.4 ± 0.8	45.4 ± 0.9
Starch (% DM)	15.8 ± 0.8	14.5 ± 1.5
NFC (% DM)	33.0 ± 1.2	31.2 ± 0.9
Fat (% DM)	2.17 ± 0.08	2.22 ± 0.15
Ca (% DM)	1.44 ± 0.00	1.40 ± 0.01
P (% DM)	0.35 ± 0.00	0.34 ± 0.00
Mg (% DM)	0.49 ± 0.02	0.52 ± 0.01
K (% DM)	1.08 ± 0.02	1.08 ± 0.03
S (% DM)	0.45 ± 0.01	0.44 ± 0.01
Na (% DM)	0.26 ± 0.01	0.25 ± 0.02
Cl (% DM)	0.79 ± 0.04	0.80 ± 0.05
DCAD (mEq/100g DM)	-11.2 ± 1.1	-11.1 ± 1.4
MP (g/kg DM)	90.5	90.2
MP Intake (g/d)*	1439	1515

* Based on 3 week average intake

Lactating Rations: Ingredient Composition (% DM)

Nutrient	CS-LM	CS-HM	MA-LM	MA-HM
BMR CS	38.0	38.0	38.0	38.0
Alfalfa Hay	7.6	7.6	7.6	7.6
Wheat Straw	6.2	6.2	6.2	6.2
Corn grain	17.1	17.1	17.1	17.1
Amino Plus	5.70	5.70	5.70	5.70
Citrus pulp	4.75	4.75	4.75	4.75
Wheat midds	4.71	4.71	4.71	4.71
Canola meal	3.80	3.80	3.80	3.80
Corn gluten feed	2.38	2.38	2.38	2.38
Gemini Protein	2.28	2.28	2.28	2.28
Soybean hulls	2.13	2.13	2.13	2.13
Energy Booster 100	1.14	1.14	1.14	1.14
Salt	0.57	0.57	0.57	0.57
Sodium bicarbonate	0.38	0.38	0.38	0.38
Calcium sulfate	0.25	0.25	0.25	0.25
Alimet	0.06	0.06	0.06	0.06
Rumensin	0.06	0.06	0.06	0.06
Calcium carbonate	1.35	1.39	1.08	0.47
Distillers	1.29	1.02	1.13	0.58
Magnesium oxide	0.13	0.38	0.05	0.08
MIN-AD	-	-	0.52	1.66
Mineral Oil	0.02	0.02	0.02	0.02
Trace minerals	0.04	0.04	0.04	0.04

Lactating Rations: Analyzed Composition (Mean ± S.D.)

Nutrient	CS-LM	CS-HM	MA-LM	MA-HM
DM (%)	43.0 ± 1.0	43.2 ± 1.1	42.8 ± 1.0	43.1 ± 1.0
CP (% DM)	14.9 ± 0.2	15.0 ± 0.3	15.2 ± 0.4	15.4 ± 0.4
ADF (% DM)	20.9 ± 0.2	21.5 ± 0.6	21.2 ± 1.0	21.1 ± 0.5
NDF (% DM)	32.5 ± 0.2	32.9 ± 0.3	33.2 ± 0.9	33.4 ± 0.9
Starch (% DM)	25.5 ± 0.9	25.3 ± 0.6	24.6 ± 0.4	25.2 ± 0.4
NFC (% DM)	45.2 ± 0.7	43.7 ± 0.3	43.5 ± 1.3	43.6 ± 1.2
Fat (% DM)	3.25 ± 0.26	3.10 ± 0.09	3.04 ± 0.13	2.87 ± 0.24
Ca (% DM)	1.21 ± 0.08	1.13 ± 0.06	1.17 ± 0.07	1.24 ± 0.03
P (% DM)	0.36 ± 0.01	0.34 ± 0.01	0.37 ± 0.01	0.36 ± 0.00
Mg (% DM)	0.35 ± 0.02	0.40 ± 0.01	0.35 ± 0.01	0.48 ± 0.00
K (% DM)	1.00 ± 0.03	0.98 ± 0.03	1.02 ± 0.03	1.01 ± 0.04
S (% DM)	0.32 ± 0.01	0.33 ± 0.02	0.33 ± 0.02	0.33 ± 0.02
Na (% DM)	0.42 ± 0.01	0.42 ± 0.00	0.43 ± 0.01	0.43 ± 0.01
Cl (% DM)	0.53 ± 0.01	0.53 ± 0.02	0.54 ± 0.01	0.53 ± 0.02
DCAD (mEq/100g DM)	8.7 ± 1.1	7.7 ± 1.2	8.9 ± 1.7	9.2 ± 1.9
MP (g/kg DM)	113.0	113.0	112.7	112.5
MP Intake (g/d)*	2158	2237	2141	2284

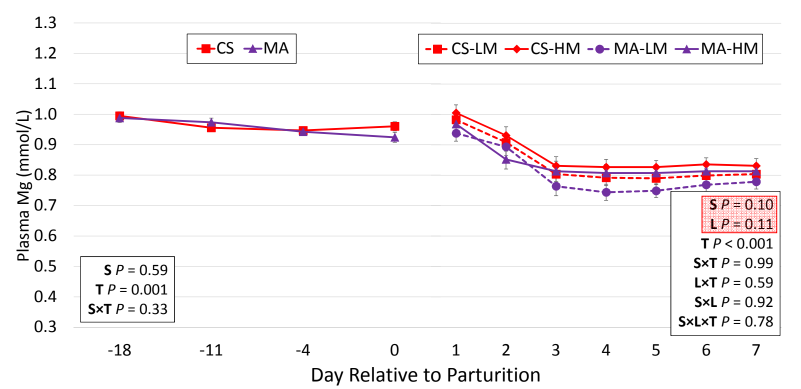
* Based on 3 week average intake

Results: Clinical Health Disorders

Disorder	CS-LM n=11	CS-HM n=11	MA-LM n=10	MA-HM n=9
Clinical hypocalcemia	0	0	0	0
Retained Placenta	0	0	1	0
Metritis	3	1	2	1
Mastitis	0	1	0	1
Displaced Abomasum	1	0	0	0

Results: Peripartum Plasma Mg

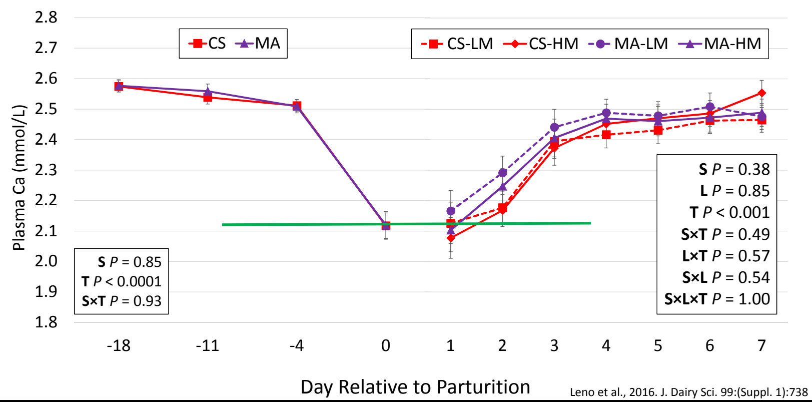
S = Source, **L** = Level, **T** = Time



Leno et al., 2016. J. Dairy Sci. 99:(Suppl. 1):738

Results: Peripartum Plasma Ca

S = Source, L = Level, T = Time



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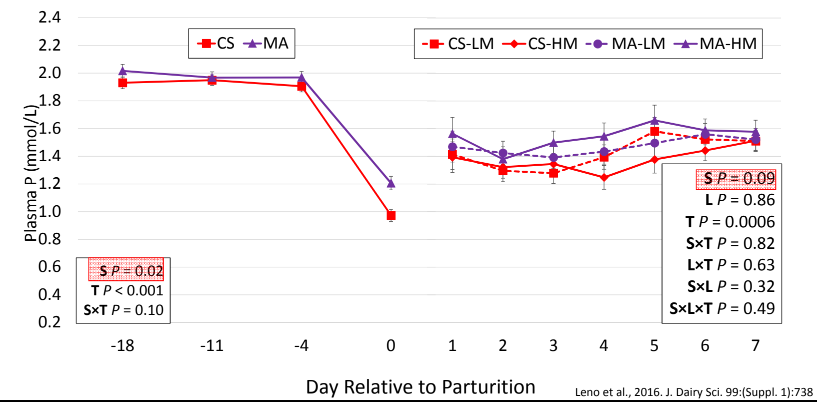
Results: Peripartum Plasma P

S = Source, L = Level, T = Time



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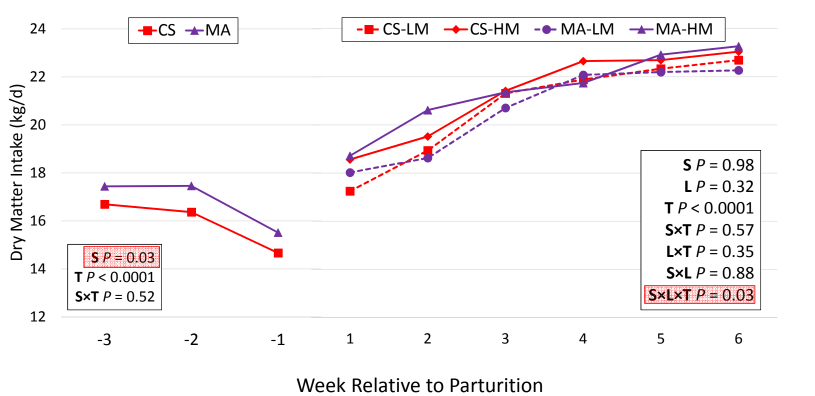
Results: Weekly DMI

S = Source, L = Level, T = Time



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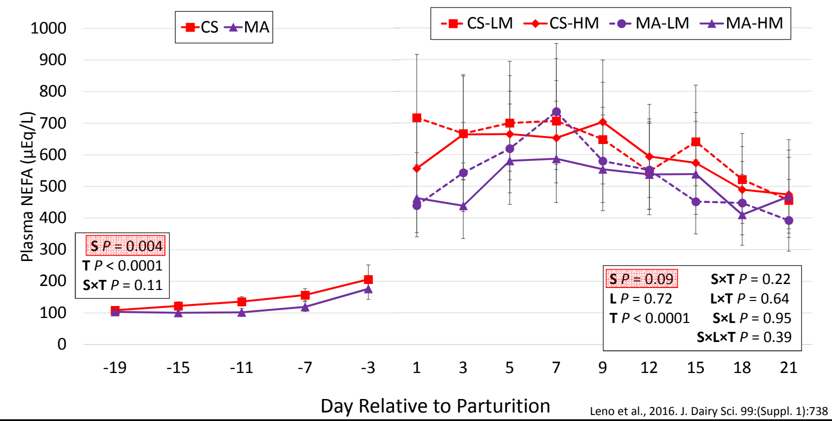
Results: Peripartum Plasma NEFA

S = Source, L = Level, T = Time



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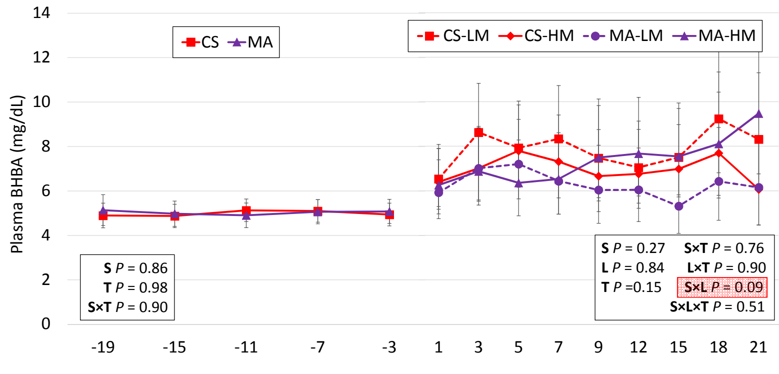
S = Source, L = Level, T = Time

Results: Peripartum Plasma BHBA

S = Source, L = Level, T = Time



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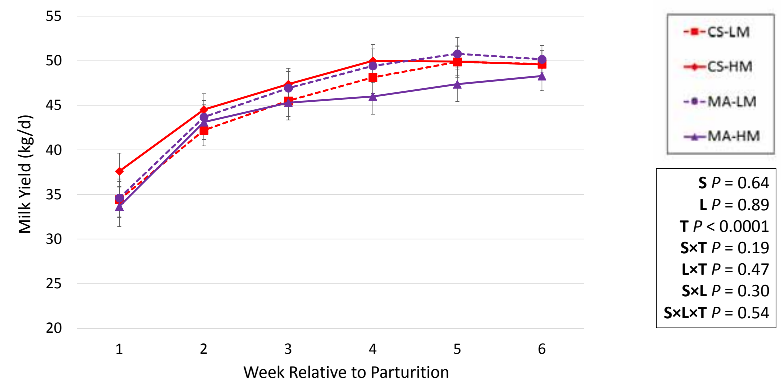
Results: Weekly Milk Yield

S = Source, L = Level, T = Time



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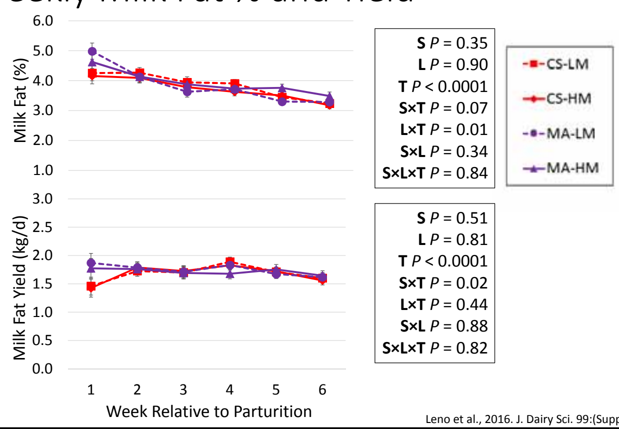
Results: Weekly Milk Fat % and Yield

S = Source, L = Level, T = Time



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Conclusions

- Feeding MIN-AD in partial replacement of common supplemental sources of Ca and Mg in the transition period resulted in:
  - Increased prepartum intake and energy balance
  - Decreased plasma NEFA throughout the transition period
  - Higher plasma P, lower plasma Mg postpartum, no effects on Ca status
  - No overall effects on milk yield
- Feeding higher dietary Mg postpartum resulted in:
  - Higher plasma Mg concentrations but no effects on other minerals
  - No overall level effects on intake, metabolites or performance
- An interaction of source, level and time was evident for postpartum DMI

Implications & Future Directions

- These data suggest:
  - Opportunity exists for strategic use of mineral sources in the transition period to promote intake and metabolic health
  - Both mineral sources and levels tested were able to support similar Ca status, health and performance
- Further work should be conducted to investigate:
  - Epidemiologic associations between lower postpartum blood Mg with health and performance
  - Mechanisms for increased intake when MIN-AD is fed in the transition period
    - Investigate effects on passage rate and/or ruminal buffering
  - Effects of source or level of Mg and Ca in different study populations

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PAPILLON
MIN - AD
Mike Brock
MERCER
CENTRAL NEW YORK FEEDS

Absorption coefficients assigned to mineral sources by NRC (2001)

	Mineral Content	Absorption Coefficient
Ca Sources		
Ca carbonate	Ca (30%)	0.75
Limestone Ca carbonate	Ca (34%)	0.70
Dolomitic limestone	Ca (22%)	0.60
Mg Sources		
Mg oxide	Mg (56%)	0.70
Mg carbonate	Mg (30%)	0.35
Dolomitic limestone	Mg (9.99%)	0.30