Effects of magnesium source and monensin on mineral absorption and balance in lactating dairy cows

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INTRODUCTION

- Dairy cattle have small amounts of labile Mg (3 – 4 g) relative to daily requirements (5 – 8 g/d).[1]
- Continuous and absorbable supplies of Mg is crucial to prevent clinical deficiencies.
- Absorption of Mg does not appear to be hormonally regulated and is absorbed pre-intestinally (i.e., the rumen). As a result,
  - Antagonism is common (e.g., high dietary K, Ca)
  - Solubility of Mg source largely affects absorption
  - Apparent absorption is highly variable (-4 – 30% of Mg intake)[2]
- Based on studies in other ruminants,[3,4] feeding monensin, which is common in the U.S. to improve feed efficiency, may improve Mg absorption.
  - Monensin may also increase absorption and balance of other macro-minerals.[5]
- Benefits of feeding monensin on Mg absorption have not been quantified and the benefit may depend on Mg source.[6]

Objective and Hypothesis

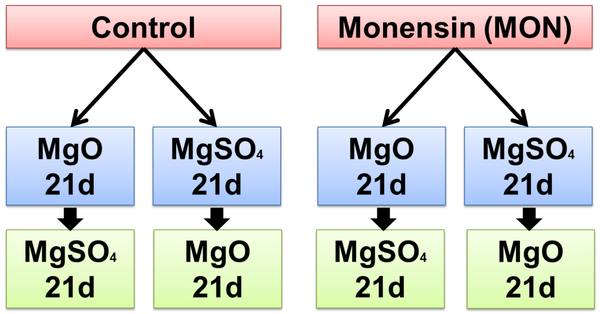
Our objective was to investigate the interaction between monensin and two common Mg sources (MgO vs. $MgSO_4$) on macro-mineral absorption and balance in lactating dairy cows fed elevated K concentrations.

We hypothesized a more soluble source of Mg (i.e., $MgSO_4$) combined with monensin would increase absorption compared to diets without monensin or with MgO. We also hypothesized monensin and Mg source may affect the absorption and balance of other macro-minerals.

METHODS

- Eighteen multiparous, Holstein cows were used in a split-plot experiment with subplot treatments in a Latin square design.
- Whole plot treatments were 0 or 14 mg/kg of dry matter (DM) of monensin (Rumensin 90, Elanco Animal Health, Greenfield, IN). The split-plot design allowed monensin treatments to be fed for the entire 42 d of the experiment without possibilities of carryover effects.
- Split-plot treatments (arranged as a 2 × 2 Latin square) were Mg (0.35% of DM) supplemented from either MgO (Animag Prilled 30/100, Martin Marietta Magnesia Specialties LLC, Baltimore, MD) or MgSO4 (Magriculture, Giles Chemical, Waynesville, NC).

Figure 1: Schematic of the split-plot experiment with Latin square subplots (9 cow/treatment).



- Each Latin square consisted of two 21-d periods with total collection of urine and feces on d 16 to 20 of each period.
- All diets had elevated K concentrations (basal diet was 1.3% K plus 0.8% K from K2CO3) to create antagonism on Mg absorption.
- Total output of urine and feces was measured in all cow-periods. Feed, fecal, urine, milk, refusal, and drinking water were assayed to calculate macro-mineral apparent absorption and balance.

- Cow-periods (n = 34) were analyzed using PROC MIXED.[6] The model included the fixed effects of monensin, Mg source, their interaction, and the random effects of group, period within group, cow within group × monensin, and residual error.

RESULTS

Table 1. Effect of supplemental Mg source and monensin on mineral absorption and balance.

	Treatment[1]							
	Control		Monensin			*P*-value		
	MgO	$MgSO_4$	MgO	$MgSO_4$	SEM	Monensin	Mg	Monensin × Mg
DM intake[2], kg/d	26.3	24.4	25.8	24.5	0.59	0.72	**0.01**	0.32
Total intake[3], g/d								
Ca	178	172	176	172	7.3	0.83	0.10	0.72
P	90	83	89	85	3.0	0.89	**0.01**	0.11
K	551	502	536	513	19.1	0.89	**0.01**	0.14
Mg	89	91	91	91	4.1	0.74	0.57	0.58
S	58	101	55	100	3.4	0.52	**0.01**	0.74
Na	73	70	66	65	6.0	0.24	0.59	0.70
Apparent absorption, %								
Ca	28.4	33.8	27.8	30.5	3.58	0.48	**0.03**	0.47
P	38.8	40.6	41.5	41.7	1.74	0.29	0.41	0.54
K	82.8	84.1	85.1	83.1	2.41	0.77	0.78	0.29
Mg	18.1	20.3	23.0	15.6	3.06	0.98	0.16	**0.03**
S	52.7	69.9	53.9	68.6	1.54	0.97	**0.01**	0.27
Na	79.7	83.1	76.8	82.0	4.61	0.61	0.22	0.81
Apparent balance, g/d								
Ca	9.2	17.0	6.9	11.1	8.32	0.47	**0.09**	0.63
P	2.5	3.0	2.4	3.3	2.42	0.92	0.58	0.87
K	48.7	56.0	55.6	36.4	18.3	0.69	0.65	0.37
Mg	4.8	5.8	8.9	4.0	2.84	0.65	0.26	0.15
S	3.6	11.9	4.1	6.7	2.64	0.32	**0.01**	0.14
Na	1.6	6.7	0.6	1.2	5.13	0.44	0.36	0.53

[1] Diets with 0 or 14 mg/kg monensin and with Mg from MgO or $MgSO_4$.
[2] Dry matter.
[3] Total intake, g/d = dietary minerals + water minerals.

- Total intake of Ca was similar across treatments (mean: 175 g/d), but absorption and balance increased with $MgSO_4$ compared to MgO (absorption: 32.2 vs 28.1%; balance: 14.1 vs 8.0 g/d).
- Total intake of Mg was similar among treatments (mean: 91 g/d), but apparent absorption had an interaction.
  - Without monensin, $MgSO_4$ increased apparent absorption 10% compared to MgO (18.1 vs 20.3%).
  - With monensin, $MgSO_4$ decreased absorption 44% compared to MgO (23.0 vs. 15.6%).
  - Differences in absorption were reflected in Mg output in urine.
- Feeding $MgSO_4$ increased S intake (99 vs 56 g/d) and absorption compared to MgO diets (69.3 vs 53.3%). Urinary S excretion accounted for about 89% of the greater absorption.

Table 2. Effect of supplemental Mg source and monensin on mineral excretion.

	Treatment[1]							
	Control		Monensin			*P*-value		
	MgO	$MgSO_4$	MgO	$MgSO_4$	SEM	Monensin	Mg	Monensin × Mg
Output, kg/d								
Milk	40.6	38.9	41.1	39.6	2.36	0.85	**0.01**	0.84
Urine	35.8	30.2	36.1	31.9	2.51	0.70	**0.01**	0.68
Milk Concentration, g/kg								
Ca	1.03	1.06	1.02	1.03	0.04	0.65	0.26	0.75
P	0.81	0.80	0.82	0.80	0.03	0.84	0.13	0.81
K	1.29	1.30	1.31	1.29	0.05	0.77	0.85	0.35
Mg	0.099	0.104	0.097	0.099	0.004	0.41	**0.03**	0.24
S	0.32	0.32	0.31	0.32	0.01	0.92	0.20	0.65
Na	0.40	0.38	0.35	0.36	0.04	0.52	0.81	0.50
Urine Output, g/d								
Ca	0.71	1.12	0.78	0.82	0.30	0.68	0.39	0.49
P	0.62	0.37	0.35	0.55	0.17	0.81	0.86	0.14
K	354	317	350	338	20.5	0.67	**0.08**	0.41
Mg	7.98	8.77	8.06	6.69	0.91	0.33	0.52	**0.04**
S	14.5	47.2	13.1	50.0	1.49	0.86	**0.01**	0.17
Na	41.3	38.2	40.0	37.2	4.44	0.76	0.42	0.98

[1] Diets with 0 or 14 mg/kg monensin and with Mg from MgO or $MgSO_4$.

Photo from Ken Chamberlain.

CONCLUSIONS

These results suggest $MgSO_4$ or SO_4^{2-} may benefit Ca homeostasis, but the mode of action is unknown. The monensin by Mg source interaction also suggest monensin should be considered when evaluating source and supplementation rate of Mg.

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ACKNOWLEDGEMENTS

The authors thank Donna Wyatt for assistance in conducting many of the assays, and the OARDC Krauss Dairy Farm staff for animal care and assistance during digestion trials.

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