Beyond buffering: Source-specific magnesium effects on rumen homeostasis and dairy cow performance

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Application

This research investigated how different types of magnesium supplements affect the rumen health and milk production of dairy cows. The findings have potential economic impacts that benefit farmers and the environment.

Introduction

Rumen homeostasis maintains a stable environment essential for ruminant health, metabolism, and microbial fermentation. Symbiotic anaerobic microbes ferment feed, supplying >70% of energy as volatile fatty acids (VFAs) and up to 90% of amino acid needs via microbial protein (Newbold et al., 2020). Key factors include stable pH (optimal ≥6.2; normal 5.5–6.2), motility, and balanced microbiota. Magnesium is critical: it serves as a cofactor in microbial energy metabolism, supports cellulolytic bacteria, and aids efficient digestion. In adult ruminants, the rumen is the main Mg absorption site, requiring consistent dietary supply since bone reserves are poorly mobilizable. Magnesium also supports parathyroid hormone function to regulate calcium and prevent milk fever. Supplemental Mg sources buffer fermentation acids, helping sustain optimal pH and prevent sub-acute ruminal acidosis (SARA; pH ≤5.8 for ≥3 h) (Nocek et al., 1997), which impairs microbial activity, feed intake, health, and performance. This study evaluates different supplemental Mg sources as buffering agents to maintain rumen homeostasis, mitigate SARA, and improve dairy cow performance.

Materials and Methods

A two-part study was conducted to investigate the effects of different Mg-based buffers on rumen parameters and cow performance. Institutional Committee for the Care and Use of Animals (CICUA) of the Austral University of Chile approved the protocol (#447/2022).

Trial 1: Four fistulated Black Friesian cows in late lactation were utilized (average liveweight = 489 kg, body condition score = 3.0, milk production = 15 kg/day at the trial initiation). Imperfect Latin square design was used, featuring three sequential treatments across three 15-day experimental periods with 12-day adaptation phase: **T0:** Base ration (BR), **T1:** BR + 125 g/day buffer A, **T2:** BR + 75 g/day buffer B, and **T3:** BR + 100 g/day buffer B. The BR included 8.5 kg of pasture silage, 6 kg of commercial concentrate, 0.9 kg of soybean meal, and 3 kg of forage turnip. Buffer A was MgO source (48.5% MgO), and Buffer B was SmartMag (Lithothamnium based buffer with 15% Mg). Ruminal pH was continuously monitored using intraruminal boluses (smaXtec v.4.7.8, Graz, Austria). Dry matter and nutrient intakes were determined daily by weighing feed offered and refusals. VFAs were analysed. Ruminal pH data were analysed with PROC MIXED with repeated measures in SAS, with animal and period as random effects and Tukey-Kramer adjustment for multiple comparisons.

Trial 2: The trial was conducted in a commercial farm to validate the most effective buffer response observed in Trial 1 in terms of dose (grams)/cost per cow per day plus the statistical outcome; 600 lactating Holstein Friesian dairy cows with a high incidence of SARA, with milk production of 9,500 L/year were used. **T1:** Control diet + $NaHCO_3$ and MgO as ruminal buffer at 250g/cow/day, **T2:** Control diet + SmartMag at 75 g/cow/day. Seven cows per treatment were randomly selected and fitted with intraruminal boluses for pH recording every 10 minutes. SARA events and duration were measured. Milk yield and components were measured daily via infrared spectrophotometry on bulk tank samples (Milkoscan System 4300, Foss Electric, Hillerød, Denmark). The herd served as the experimental unit in a sequential switchback design with wash-in periods. Data were analysed using with PROC MIXED with treatment as fixed effect, days in milk as fixed covariate, and cow and period as random effects. Treatment means were compared using t-tests.

Results and Discussion

Only ruminal pH varied among treatments; T1 ≠ T3 ($P < 0.05$), T1=T2 and T2=T3 (Table 1). This pattern aligns with VFAs: T2 and T3 showed numerically higher total VFA concentrations than T1, but T2 achieved it with a lower dose.

Table 1. Nutritional and biochemical variables recorded per treatment (Trial 1).

	Treatments					
Variable	T0	T1	T2	T3	SEM	P
DM (kg)	16.20	16,41	16,50	16,33	0,20	0,98
NDF (kg)	6.05	6,10	6,20	6,02	0,24	0,98
NSC (kg)	5.64	5,69	5,70	5,63	0,09	0,91
pH	5.63a	5,83b	5,91cb	5,95c	0,106	<0,01
NH_3, mg/L	5.90	6,41	6,74	5,68	0,430	0,41
VFA totals (mmol/L)	125.5	126,8	132,2	128,4	8,2	0,71
Acetate (%)	66.2	67,8	66,4	65,3	0,8	0,19
Propionate (%)	11.5	10,1	11,3	11,4	0,7	0,26
Butyrate (%)	11.2	11,6	11,8	12,4	0,5	0,38
Valerate (%)	2.9	2,5	2,9	3,9	0,2	0,71

a; b; c: different letters indicate statistical difference ($P < 0.05$). NSC: Non-structural carbohydrates.

In Trial 2, T2 (SmartMag) increased average daily ruminal pH compared to Control (Table 2). This improvement reduced the proportion of cows experiencing SARA from 71% to 24% and shortened SARA duration from 11.2 hours to 3.5. This indicates that SmartMag enhanced rumen stability and homeostasis, substantially lowering SARA incidence and severity in this challenged herd. The improved rumen environment, with greater microbial activity, translated into higher milk yield and favourable shifts in milk composition (Table 2).

Table 2. Performance parameters recorded per treatment (Trial 2).

Variable	T1 (Control)*	T2 (SmartMag)**	P-value	SEM
Milk Yield (kg/d)	31.10	33.13	< 0.001	0.204
Milk Butter (kg/d)	1.06	1.30	< 0.001	0.016
Milk Protein (kg/d)	0.81	0.82	0.505	0.012
Total Solids (kg/d)	1.87	2.12	< 0.001	0.018
Rumen pH	5.84	6.05	< 0.001	0.041

* NaHCO3 and MgO as ruminal buffer 250g/cow/day. ** SmartMag (Devenish Nutrition Ltd) at 75 g/cow/day.

Conclusions

Buffer B outperformed Buffer A, with significantly higher ruminal pH, numerically greater ammonia-N, and increased VFA production. It exhibited a superior dose-response for SARA mitigation, with T2 providing the optimal effect. Both buffers kept ruminal parameters within healthy ranges and effectively controlled acidity, but Buffer B achieved equivalent or better rumen homeostasis at a substantially lower inclusion rate. Trial 2 confirms Buffer B as a more efficient buffering agent for preventing SARA and improving dairy cow performance under commercial high-risk conditions.

References

Newbold, C.J.; Ramos-Morales, E. Review: Ruminal microbiome and microbial metabolome: Effects of diet and ruminant host. Animal 2020, 14, s78–s86.

Nocek, J.E. Bovine acidosis: Implications on laminitis. J. Dairy Sci. 1997, 80, 1005–1028