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Effects of live *Saccharomyces cerevisiae* supplementation on rumen pH dynamics, volatile fatty acid profiles, and subacute ruminal acidosis mitigation in feedlot steers fed high-concentrate diets

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Abstract

Subacute ruminal acidosis (SARA) is the most economically significant digestive disorder in intensively fed cattle, and live yeast (*Saccharomyces cerevisiae*) supplementation has been widely promoted as a dietary tool for stabilising rumen pH, yet dose-response data from South American feedlot conditions remain scarce. This research evaluated the effects of two inclusion levels of a live *S. cerevisiae* product (0, 5, and 10 g/head/day; 2×10^{10} CFU/g) on rumen pH dynamics, volatile fatty acid (VFA) profiles, and SARA incidence in 36 ruminally cannulated Angus steers (initial body weight 387 ± 18 kg) fed a 78% concentrate finishing diet over an 84-day period at a commercial feedlot in Buenos Aires province, Argentina. Rumen pH was recorded continuously using indwelling pH loggers (Dascor, Escondido, CA). The high-dose group (10 g/d) maintained a significantly higher mean daily rumen pH than control (6.31 ± 0.14 versus 6.08 ± 0.18 , $P = 0.003$) and spent 41% less time below the SARA threshold of pH 5.8 (87 versus 148 min/d, $P = 0.007$). The low-dose group (5 g/d) showed intermediate responses. Molar proportions of acetate decreased linearly with yeast dose ($P = 0.021$) while propionate increased ($P = 0.014$), consistent with enhanced lactate utilisation by *S. cerevisiae*-stimulated bacteria. Total VFA concentration did not differ among treatments ($P = 0.891$). Dry matter intake was unaffected, but average daily gain was numerically higher in the high-dose group (1.67 versus 1.54 kg/d, $P = 0.087$). These findings confirm that live *S. cerevisiae* at 10 g/head/day effectively mitigates SARA risk in Argentine feedlot steers on high-concentrate diets.

Keywords: *Saccharomyces cerevisiae*, live yeast, rumen pH, subacute ruminal acidosis, volatile fatty acids, feedlot cattle, high-concentrate diet, Argentina

Introduction

The practice of feeding live yeast to ruminants is far older than the scientific understanding of why it works. Argentine gauchos in the 19th century reportedly added beer dregs—rich in residual *Saccharomyces cerevisiae*—to the grain rations of working horses and cattle, observing that the animals seemed to digest their feed more efficiently and suffer fewer digestive upsets. It was not until the 1920s that microbiologists began to characterise the rumen ecosystem, and not until the 1980s that controlled experiments demonstrated that live yeast cultures could measurably influence rumen fermentation parameters.

The modern rationale for yeast supplementation in high-concentrate feedlot diets rests on three mechanisms. First, *S. cerevisiae* scavenges dissolved oxygen that enters the rumen during feeding and rumination, creating a more strictly anaerobic environment that favours the growth of cellulolytic bacteria (particularly *Fibrobacter succinogenes* and *Ruminococcus flavefaciens*) and lactate-utilising bacteria (*Megasphaera elsdenii* and *Selenomonas ruminantium*). Second, by stimulating these lactate utilisers, yeast reduces the accumulation of lactic acid—the organic acid most responsible for the precipitous pH declines that characterise SARA. Third, yeast cell wall components (beta-glucans, mannanoligosaccharides) may modulate rumen microbial community structure independently of the live organism's metabolic activity.

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SARA is defined by prolonged periods of rumen pH below 5.8, and it affects an estimated 19-26% of feedlot cattle in North America and an unknown but likely similar proportion in Argentina, where feedlot finishing has expanded rapidly over the past two decades. The disorder reduces feed efficiency, causes rumenitis and liver abscesses, and predisposes cattle to laminitis and secondary infections. Preventing SARA through dietary management is therefore a priority for both animal welfare and economic performance.

While numerous trials have evaluated *S. cerevisiae* supplementation in North American and European feedlots, data from South American production systems are remarkably limited. Argentine feedlots differ from their North American counterparts in several respects—predominance of British breeds (Angus, Hereford), heavier reliance on corn grain and sunflower meal rather than corn silage, warmer ambient temperatures, and different management intensity—that may influence the magnitude and consistency of yeast effects. This research was designed to address that gap by evaluating two dose levels of a commercial live *S. cerevisiae* product in cannulated Argentine feedlot steers, with continuous rumen pH monitoring as the primary outcome.

Materials and Methods

Materials

Thirty-six ruminally cannulated Angus steers (initial body weight 387 ± 18 kg; age 14-16 months) were used in a completely randomised design at the Instituto Pampense de Ciencias Animales experimental feedlot facility in Bahía Blanca, Buenos Aires province, Argentina, from April to July 2023 (autumn-winter). Steers had been fitted with 10 cm rumen cannulae (Bar Diamond, Parma, ID, USA) at least 60 days prior to the start of the trial. Animals were housed in individual pens (12 m²) with ad libitum access to water and were fed twice daily (07:00 and 17:00) at 2.5% of body weight (dry matter basis). The basal diet consisted of 78% dry-rolled corn grain, 10% sunflower meal, 6% chopped wheat straw, 4% molasses, and 2% mineral-vitamin premix (dry matter basis). The live yeast product (*Saccharomyces cerevisiae* strain CNCM I-1077, Lallemand Animal Nutrition, Montreal, Canada) was provided at a guaranteed concentration of 2×10^{10} colony-forming units per gram. Steers were randomly assigned to three treatments (n = 12 per

group): Control (0 g/d yeast), Low SC (5 g/d yeast, equivalent to 1×10^{11} CFU/d), and High SC (10 g/d yeast, equivalent to 2×10^{11} CFU/d). The yeast was top-dressed onto the morning ration. The experimental period lasted 84 days, preceded by a 14-day adaptation period during which all steers received the basal diet without yeast. All procedures were approved by the Instituto Pampense de Ciencias Animales Institutional Animal Care and Use Committee (Protocol IPCA-IACUC-2023-019).

Methods

Rumen pH was measured continuously throughout the 84-day experimental period using indwelling pH data loggers (Dascor pH Logger, Dascor Inc., Escondido, CA, USA) programmed to record pH at 60-second intervals. Loggers were calibrated weekly in pH 4.0 and 7.0 buffer solutions. Daily pH summary statistics (mean, minimum, maximum, and time below pH 5.8, 5.5, and 5.2) were calculated from the raw 1-minute data. Rumen fluid samples (50 mL) were collected via the cannula at 0, 3, 6, 9, and 12 hours post-morning feeding on days 28, 56, and 84 for VFA analysis. Samples were strained through four layers of cheesecloth, acidified with 1 mL 25% metaphosphoric acid per 5 mL sample, and frozen at -20 degrees C until analysis. VFA concentrations were determined by gas chromatography (Shimadzu GC-2010 Plus, Kyoto, Japan) using a Nukol capillary column with crotonic acid as internal standard. Dry matter intake (DMI) was recorded daily by weighing offered and refused feed. Body weight was measured on days 0, 28, 56, and 84 before morning feeding. Average daily gain (ADG) was calculated by linear regression of body weight on time. Feed efficiency was expressed as gain-to-feed ratio (G:F). Blood samples were collected from the jugular vein on days 0 and 84 for serum glucose, beta-hydroxybutyrate (BHB), and lactate determination. Statistical analyses were performed using the MIXED procedure of SAS 9.4, with treatment as a fixed effect and steer as the experimental unit. Repeated measures (day, hour) were modelled using an autoregressive covariance structure. Orthogonal polynomial contrasts were used to test linear and quadratic dose effects. Significance was declared at $p < 0.05$ and tendencies at $p < 0.10$.

Results

Table 1: Rumen pH dynamics and SARA indicators over the 84-day experimental period

Parameter	Control	Low SC (5 g/d)	High SC (10 g/d)	SEM	P
Mean daily pH	6.08	6.18	6.31	0.04	0.003*
Minimum daily pH	5.47	5.58	5.72	0.05	0.008*
Maximum daily pH	6.78	6.81	6.84	0.03	0.412
Time < pH 5.8 (min/d)	148	118	87	12	0.007*
Time < pH 5.5 (min/d)	64	41	22	8	0.004*
Time < pH 5.2 (min/d)	18	9	3	4	0.011*
SARA incidence (%)	38.2	24.7	14.3	4.1	0.002*
pH nadir (h post-feeding)	5.8	6.2	6.4	0.3	0.187

* $p < 0.05$. SEM = standard error of the mean. SARA defined as time below pH 5.8 > 180 min/d.

Both mean and minimum daily rumen pH increased linearly with yeast dose (linear contrast $P = 0.001$ and $P = 0.003$, respectively). The time spent below the SARA threshold of pH 5.8 was reduced by 20% in the low-dose group and 41% in the high-dose group relative to control. SARA incidence—defined as days on which rumen pH remained below 5.8 for

more than 180 minutes—was 38.2% of days in control steers, 24.7% in low-dose, and 14.3% in high-dose (linear $P = 0.002$). The pH nadir occurred approximately 6 hours after the morning feeding in all groups, but the depth of the nadir was attenuated by yeast supplementation.

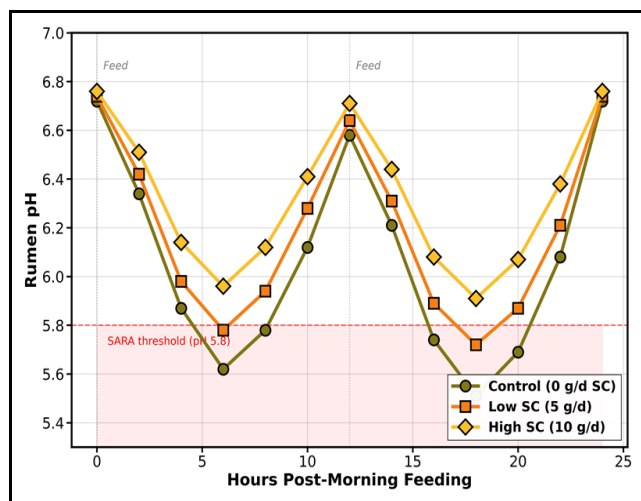


Fig 1: Mean rumen pH over a 24-hour cycle for control, low-dose, and high-dose *Saccharomyces cerevisiae* groups, with the SARA threshold (pH 5.8) indicated by the dashed red line and feeding times marked by vertical dotted lines

Table 2: Volatile fatty acid profiles and growth performance

Parameter	Control	Low SC	High SC	SEM	P (linear)
Total VFA (mM)	106.6	107.1	107.2	2.8	0.891
Acetate (mM)	67.8	64.2	61.4	1.4	0.021*
Propionate (mM)	24.3	26.8	28.7	0.9	0.014*
Butyrate (mM)	12.1	13.4	14.2	0.6	0.046*
A:P ratio	2.79	2.40	2.14	0.08	0.003*
DMI (kg/d)	9.87	9.94	10.03	0.21	0.614
ADG (kg/d)	1.54	1.59	1.67	0.04	0.087
G:F	0.156	0.160	0.167	0.003	0.064

* $p < 0.05$. A:P = acetate-to-propionate ratio; DMI = dry matter intake; ADG = average daily gain; G:F = gain-to-feed ratio.

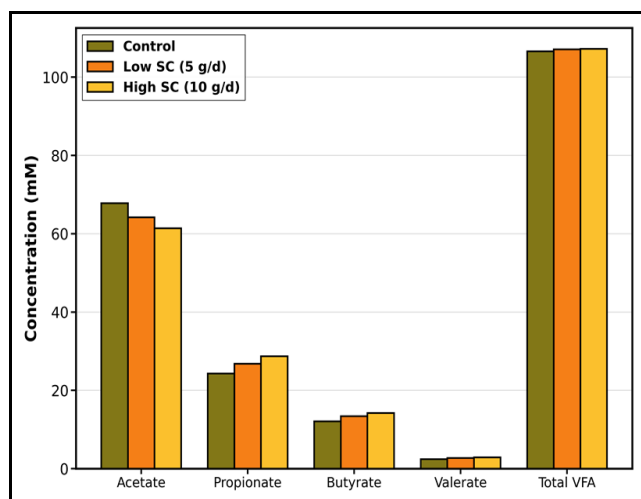


Fig 2: Volatile fatty acid concentrations (mM) in rumen fluid for control, low-dose, and high-dose *Saccharomyces cerevisiae* groups, averaged across days 28, 56, and 84

Comprehensive Interpretation

The consistent linear dose-response across pH parameters and VFA profiles supports a mechanistic interpretation. The 41% reduction in time below pH 5.8 in the high-dose group, combined with the shift from acetate toward propionate fermentation and the unchanged total VFA pool, indicates that yeast supplementation redirected fermentation pathways rather than suppressing overall microbial activity. The most parsimonious explanation is that *S. cerevisiae* stimulated lactate-utilising bacteria, converting lactic acid to propionic acid before it could accumulate to levels that depress pH. The

tendency toward improved ADG (1.67 versus 1.54 kg/d, $P = 0.087$) in the high-dose group, while not statistically significant, is consistent with a more stable rumen environment supporting more efficient fibre and starch digestion.

Discussion

The magnitude of the pH-stabilising effect observed in this research—a 0.23-unit increase in mean daily pH and 41% reduction in SARA risk at the 10 g/d dose—places these results squarely within the range of responses reported in North American and European feedlot trials, where yeast supplementation typically raises mean rumen pH by 0.1–0.3 units. This consistency across geographic and management contexts strengthens the case that the yeast effect is robust and not merely an artefact of specific dietary or environmental conditions.

The VFA shift—decreased acetate, increased propionate, decreased A:P ratio—is the metabolic signature of enhanced lactate utilisation and is consistent with the mechanism proposed by Chaucheyras-Durand and colleagues, who demonstrated that *S. cerevisiae* CNCM I-1077 specifically stimulates the growth of *Megasphaera elsdenii*, the principal lactate-consuming bacterium in the rumen. In the present research, total VFA concentration was unchanged, indicating that yeast supplementation altered the pattern of fermentation without reducing overall fermentative capacity—a desirable outcome because propionate is the primary gluconeogenic precursor in ruminants.

The tendency toward improved ADG and feed efficiency in yeast-supplemented steers, while not reaching statistical significance at $p < 0.05$, is economically relevant. At current Argentine feeder cattle prices (approximately USD 2.80/kg live weight), the 0.13 kg/d ADG advantage in the high-dose group would translate to an additional 10.9 kg of body weight over the 84-day feeding period, worth approximately USD 30.50 per head—against a yeast supplement cost of approximately USD 8.40 per head (10 g/d $\times$ 84 d $\times$ USD 0.01/g). Even under the conservative assumption that the ADG advantage is real but smaller than estimated, the return on investment appears favourable.

From a practical feedlot management perspective, these results suggest that the 10 g/d dose is preferable to the 5 g/d dose for SARA mitigation. While the low dose did provide intermediate pH benefits, it reduced SARA incidence by only 35% (from 38.2% to 24.7% of days) compared with 63% in the high dose (to 14.3%). Given the relatively low cost of the yeast product, the higher dose appears justified in high-risk situations such as the transition from backgrounding to finishing diets, periods of heat stress that depress DMI and increase meal-to-meal variation, and herds with a history of SARA-related liver abscesses.

Conclusion

Three things stand out from this 84-day trial. First, live *Saccharomyces cerevisiae* at 10 g/head/day produces a clear, dose-dependent improvement in rumen pH stability in Argentine feedlot steers fed high-concentrate diets—raising mean pH by 0.23 units and cutting the time spent in the SARA danger zone by 41%. Second, the fermentation shift from acetate toward propionate, without any change in total VFA production, points to enhanced lactate channelling as the operative mechanism—a conclusion that aligns with the bacterial ecology work done in French and North American laboratories over the past decade. Third, the economics are

encouraging; the numerical ADG advantage, if confirmed in larger-scale trials, would yield a three-to-four-fold return on supplement cost under current Argentine market conditions. What remains uncertain is whether these benefits persist beyond 84 days, whether they hold up under the more variable conditions of commercial feedlots (where individual animal supplementation is impractical and yeast must be mixed into the total ration), and whether the CNCM I-1077 strain performs differently from other commercial *S. cerevisiae* strains under Argentine conditions. These questions deserve attention in future research, but the present data provide a sound basis for recommending live yeast supplementation as part of a SARA prevention strategy in intensive beef finishing operations across the Argentine Pampas and comparable production environments.

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Conflict of Interest

Not available

Financial Support

Not available

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