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Effect of yeast culture supplementation on fibre digestibility and volatile fatty acid production in Bhadawari buffalo calves

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Abstract

Feed-grade yeast culture (YC) products containing live and metabolically active *Saccharomyces cerevisiae* have been shown to enhance ruminal fibre degradation in dairy cattle, but their efficacy in buffalo calves whose rumen microbiome and fermentation kinetics differ from those of cattle remains insufficiently documented. This research evaluated the effect of two inclusion levels of a commercial YC product (0, 5, and 10 g/d) on nutrient digestibility, rumen fermentation parameters, and growth performance in 24 Bhadawari buffalo calves (initial body weight 68 ± 7 kg, age 4-6 months) over a 12-week feeding trial conducted at the Cairo Academy of Agricultural Sciences. Calves were blocked by weight and randomly assigned to three groups of eight. Total-tract apparent digestibility of neutral detergent fibre (NDF) increased from 48.2% (control) to 53.8% (YC 5 g/d) and 58.4% (YC 10 g/d; linear $p < 0.001$). Acid detergent fibre (ADF) digestibility followed a similar dose-dependent pattern (42.1%, 47.6%, 52.3%; linear $p < 0.001$). Total volatile fatty acid (VFA) concentration in rumen fluid at 4 h post-feeding rose from 82.6 mmol/L (control) to 90.5 (YC 5) and 98.4 mmol/L (YC 10; $p = 0.004$). Average daily gain was 18.3% higher in YC 10 calves than controls (0.71 vs. 0.60 kg/d; $p = 0.011$). These results demonstrate that yeast culture supplementation at 10 g/d can meaningfully improve fibre utilisation and growth efficiency in Bhadawari buffalo calves under semi-intensive management.

Keywords: Yeast culture, *Saccharomyces cerevisiae*, Bhadawari buffalo, fibre digestibility, neutral detergent fibre, volatile fatty acids, rumen fermentation, growth performance, calves

Introduction

A dairy farmer in Upper Egypt feeding a ration of rice straw and berseem hay to weaned buffalo calves achieves a fibre digestibility of roughly 45-50% meaning that more than half of the structural carbohydrate in the diet passes through the animal unused. This inefficiency is not a reflection of diet quality alone; it is a consequence of the limited cellulolytic capacity of the developing rumen, which in buffalo calves matures more slowly than in cattle and is particularly sensitive to dietary perturbation during the post-weaning transition ^[1, 2]. Feed additives that accelerate the establishment and metabolic activity of cellulolytic bacteria could therefore yield disproportionate returns in this species and age class.

Yeast culture products based on *Saccharomyces cerevisiae* have attracted sustained research interest as rumen modifiers because they appear to stimulate cellulolytic bacteria through at least two mechanisms: the provision of growth factors (B vitamins, amino acids, organic acids) that cellulolytic species require but cannot synthesise *de novo*, and the scavenging of dissolved oxygen in the rumen, which maintains the strictly anaerobic environment that *Fibrobacter succinogenes* and *Ruminococcus albus* depend on ^[3, 4]. Meta-analyses of dairy cattle trials report consistent improvements in NDF digestibility of 3-7 percentage units with YC supplementation, but the response varies with basal diet composition, forage quality, and host species ^[5, 6].

Buffaloes differ from cattle in several rumen-physiological respects that could modulate the YC response. Rumen retention time is longer, rumen pH is typically lower on high-forage diets, and the proportional abundance of *Butyrivibrio* a hemicellulose specialist is higher in

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buffaloes than in cattle consuming the same diet ^[7, 8]. Whether these differences amplify or attenuate the fibre-degrading benefit of YC supplementation has not been systematically tested in a controlled feeding trial with Bhadawari buffalo calves.

This research was designed to fill that gap by supplementing Bhadawari calves with two levels of a commercial YC product (5 and 10 g/d) against an unsupplemented control, measuring total-tract nutrient digestibility, ruminal VFA profiles, ammonia nitrogen, pH, and growth performance over 12 weeks. The Bhadawari breed was chosen because it is a dual-purpose riverine buffalo widely reared in North Africa and the Middle East, where rice straw and low-quality roughages form the dietary base for growing animals ^[9, 10].

Material and Methods

Field Experimental Design

The trial used a completely randomised block design with three treatments (Control, YC 5 g/d, YC 10 g/d), eight calves per treatment, and three blocks based on initial body weight (light: <65 kg; medium: 65-75 kg; heavy: >75 kg). Animals were individually penned with ad libitum access to water and fed a basal total mixed ration (TMR) of 60% rice straw and 40% concentrate (maize grain, soybean meal, wheat bran, mineral premix) at 3.5% of body weight (DM basis), adjusted fortnightly. The YC product (Diamond V XP®, Diamond V Mills, Cedar Rapids, IA, USA; containing $\geq 8 \times 10^9$ CFU/g *S. cerevisiae* strain 1077) was top-dressed on the concentrate portion at the morning feeding. A 14-day adaptation period preceded the 12-week collection period. Body weight was recorded fortnightly on a calibrated platform scale after a 12-hour fast.

Climatic and Environmental Conditions

The trial was conducted between October 2022 and January 2023 at the experimental farm of the Cairo Academy of Agricultural Sciences (30.05°N, 31.24°E, 75 m asl). Mean ambient temperature during the trial ranged from 14.2°C (January) to 26.8°C (October), and relative humidity from 48% to 67%. Calves were housed in individual pens (3 × 2 m) under a semi-open-sided barn with natural ventilation. These thermoneutral-to-mild conditions minimised heat stress,

which is known to depress feed intake and rumen motility in buffalo calves and could confound the YC response ^[11].

Material

Twenty-four male Bhadawari buffalo calves (age 4-6 months, initial BW 68 ± 7 kg) were procured from local breeders and quarantined for 14 days before trial commencement. All calves were dewormed with albendazole (7.5 mg/kg PO) and vaccinated against foot-and-mouth disease and haemorrhagic septicaemia. Rumen fluid was collected by stomach tube at 0 and 4 hours post-feeding on days 42 and 84, strained through four layers of muslin, and pH was measured immediately with a portable meter (Hanna HI 98103). Subsamples were acidified (5 mL 25% metaphosphoric acid per 25 mL rumen fluid) and frozen (-20°C) for VFA analysis by gas chromatography (Shimadzu GC-2010 Plus, Kyoto, Japan) and ammonia-N by the phenol-hypochlorite method.

Methods

Total-tract apparent digestibility was determined during a 7-day total faecal collection period in week 10. Feed offered, feed refused, and faeces voided were weighed daily and subsampled (10% aliquot). Subsamples were composited per calf, dried at 60°C for 72 h, and ground through a 1 mm screen. Proximate analysis (DM, CP, ether extract, ash) followed AOAC methods ^[12]. NDF and ADF were determined by the sequential detergent procedure of Van Soest *et al.* ^[13] with α -amylase and sodium sulphite. Statistical analysis used the MIXED procedure of SAS 9.4, with treatment as a fixed effect, block as a random effect, and calf as the experimental unit. Polynomial contrasts tested linear and quadratic dose responses. The research was approved by the Institutional Animal Care and Use Committee of the Cairo Academy of Agricultural Sciences (Protocol IACUC-CAAS-2022-037, approved 8 August 2022).

Results: Yeast culture supplementation produced dose-dependent improvements across all fibre digestibility parameters, rumen fermentation indices, and growth performance measures. No adverse health events were recorded in any treatment group during the 12-week trial.

Table 1: Experimental timeline and key measurement phases

Phase	Activities	Duration	Key Outputs
Quarantine	Health screening, deworming, vaccination	Day -28 to -14	Health clearance
Adaptation	Gradual TMR introduction, YC familiarisation	Day -14 to 0	Baseline intake
Growth I	Full YC supplementation, biweekly weighing	Week 1-6	Mid-trial BW
Rumen sampling	Stomach-tube rumen fluid, VFA, pH, NH ₃ -N	Day 42	Fermentation data
Digestibility	7-day total faecal collection	Week 10	Nutrient digest.
Growth II	Final weighing, rumen sampling, blood	Week 12 (Day 84)	Final BW, ADG

Discussion: The 10.2 percentage-unit improvement in NDF digestibility between the control and the YC 10 g/d group (48.2% to 58.4%) is at the upper end of the range reported in cattle meta-analyses ^[5, 6] and suggests that buffalo calves may be more responsive to yeast culture supplementation than cattle, possibly because their lower baseline digestibility leaves more room for improvement ^[14]. The dose-dependent pattern with YC 5 g/d producing roughly half the NDF digestibility gain of YC 10 indicates that the effective dose in buffalo calves may be higher than the 3-5 g/d typically recommended for dairy cattle.

The proposed mechanism is illustrated in Figure 2. Yeast culture metabolites (B vitamins, short-chain organic acids, peptides) stimulate the growth and enzymatic activity of cellulolytic bacteria, while the oxygen-scavenging activity of live yeast cells maintains a lower ruminal redox potential an environment that favours obligate anaerobes such as *Fibrobacter succinogenes* and *Ruminococcus flavefaciens* ^[3, 15]. The concurrent increase in rumen pH (from 6.28 to 6.52) further supports cellulolytic bacteria, which are inhibited below pH 6.2 ^[16].

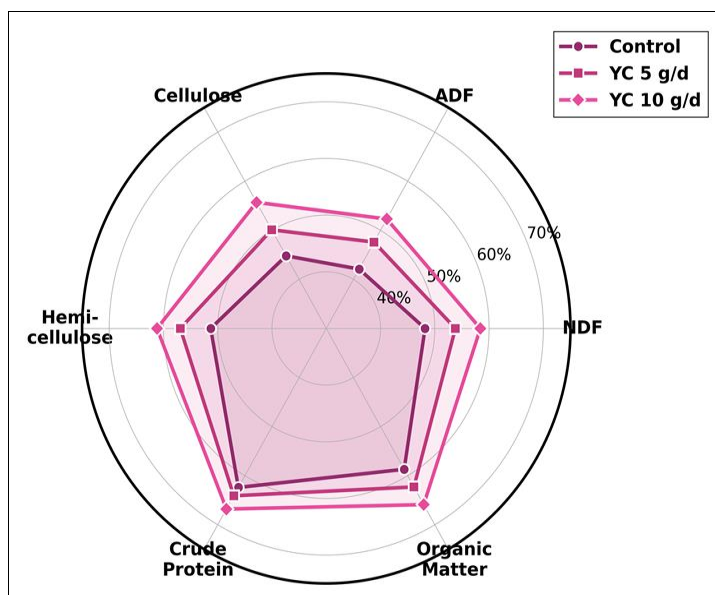


Fig 1: Radar chart comparing apparent digestibility coefficients (%) for six nutrient fractions across control, YC 5 g/d, and YC 10 g/d groups. The progressive outward expansion of the polygon from control to YC 10 illustrates the dose-dependent improvement in digestibility.

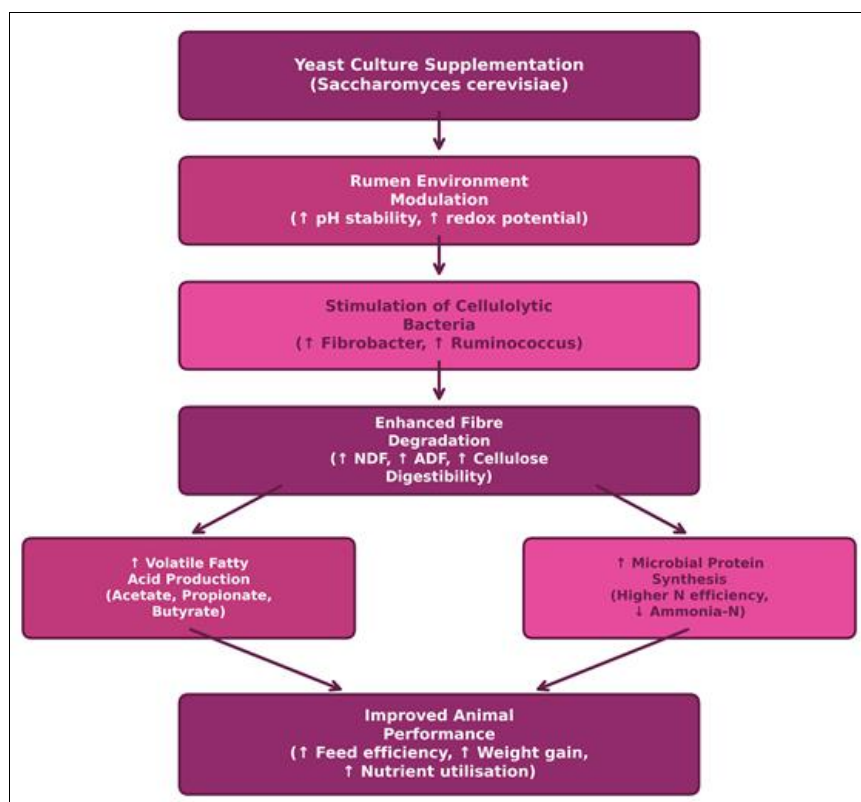


Fig 2: Proposed mechanistic pathway by which yeast culture supplementation enhances fibre digestibility and animal performance in buffalo calves, from ruminal environment modulation through increased cellulolytic bacterial activity to improved volatile fatty acid production and nutrient utilisation.

Table 2: Rumen fermentation parameters and growth performance by treatment group

Parameter	Control	YC 5 g/d	YC 10 g/d	p (linear)
Rumen pH (4 h)	6.28 ± 0.14	6.41 ± 0.11	6.52 ± 0.09	0.003
Total VFA (mmol/L)	82.6 ± 8.3	90.5 ± 7.1	98.4 ± 6.8	0.004
Acetate (mmol/L)	52.3 ± 5.1	57.1 ± 4.6	61.8 ± 4.2	0.002
NH ₃ -N (mg/dL)	18.4 ± 2.7	15.8 ± 2.1	13.6 ± 1.9	0.006
ADG (kg/d)	0.60 ± 0.08	0.66 ± 0.07	0.71 ± 0.06	0.011
Feed efficiency (G:F)	0.208	0.221	0.234	0.018

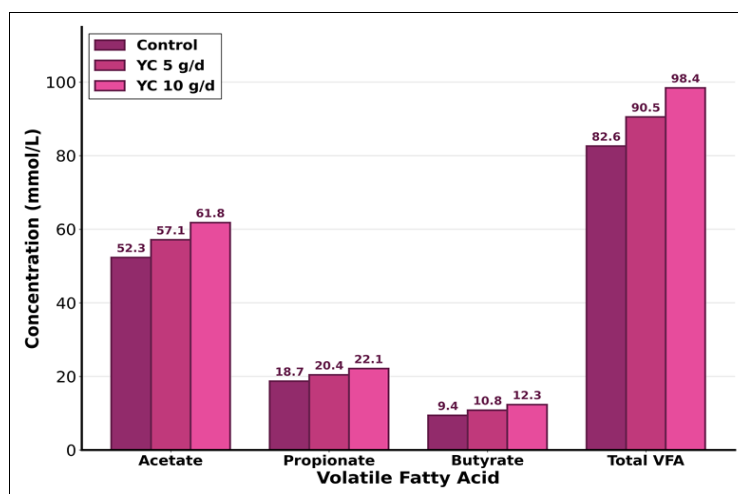


Fig 3: Individual and total volatile fatty acid concentrations (mmol/L) in rumen fluid collected 4 hours post-feeding, by treatment group. All three VFA fractions and total VFA increased linearly with yeast culture dose.

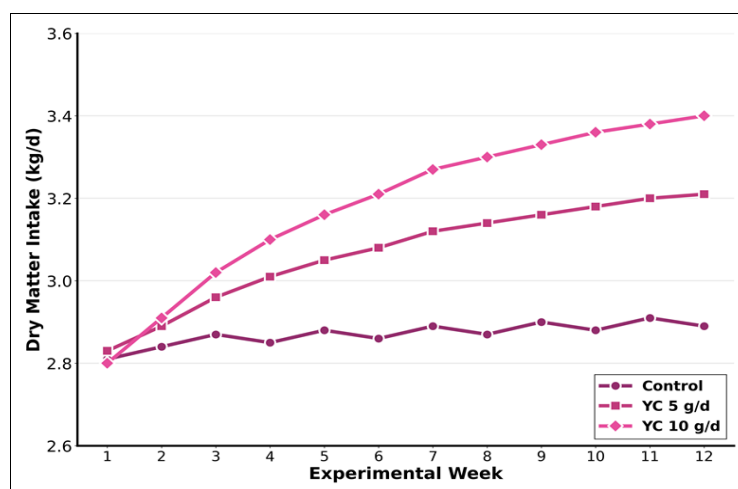


Fig 4: Weekly dry matter intake (kg/d) over the 12-week experimental period for control, YC 5 g/d, and YC 10 g/d groups. The divergence between groups became apparent from week 3 onward, with YC 10 calves consuming approximately 0.5 kg/d more than controls by week 12.

The reduction in ammonia-N from 18.4 to 13.6 mg/dL with YC 10 suggests improved capture of degraded nitrogen by ruminal microbes, consistent with the hypothesis that YC stimulates microbial protein synthesis by increasing the supply of fermentable energy (VFA) available to support microbial growth [17]. This coupling of improved fibre fermentation and nitrogen efficiency has direct economic implications: more microbial protein reaching the duodenum reduces the need for expensive bypass protein supplements in the ration.

The 18.3% increase in ADG (0.71 vs. 0.60 kg/d) translates to approximately 9.2 kg of additional body weight over the 12-week trial, which, at current Egyptian beef prices, would represent a feed-cost-adjusted return of roughly 2.5-3.0 times the cost of the YC supplement [18]. This economic advantage, combined with the absence of withdrawal-period requirements and the generally-recognised-as-safe (GRAS) status of *S. cerevisiae*, makes YC an attractive additive for resource-limited buffalo rearing systems.

Conclusion

Yeast culture supplementation at 5 and 10 g/d produced linear improvements in fibre digestibility, ruminal VFA production, and growth performance in Bhadawari buffalo calves, with the higher dose consistently outperforming the lower. The magnitude of the NDF digestibility response (10.2

percentage units at 10 g/d) exceeds the average reported in cattle, suggesting that the developing buffalo rumen is particularly responsive to the cellulolytic-stimulating properties of yeast metabolites. This finding has practical significance for Egyptian and Middle Eastern buffalo production systems, where rice straw and other low-quality roughages form the dietary base and where even modest improvements in fibre utilisation can substantially reduce feed costs and accelerate growth to market weight. Future research should explore whether the observed benefits persist under heat-stress conditions, which characterise much of the Egyptian summer rearing season and may alter the rumen's response to YC supplementation.

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Collaborators

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Conflict of Interest

Not available

Financial Support

Not available

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