BIOTROPIA ISSN: 0215-6334 | e-ISSN: 1907-770X
The Southeast Asian Journal of Tropical Biology
Vol. 34 No. 1, 2027: 12 - 26
DOI: 10.11598/btb.2027.34.1.2756

Research Paper

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DIETARY YEAST AND COCONUT OIL MODULATE DIGESTIVE STABILITY INDICATORS IN HORSES

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ARTICLE HIGLIGHTS

- Yeast (*Saccharomyces cerevisiae*) and coconut oil reduced blood triglyceride levels
- Yeast reduce the number of E.coli and lactic acid bacteria in the equine cecum
- Maintaining fecal pH within a stable range is critical in preventing acidosis
- Contributes to the enhancement of the equine immune system

Article Information

Received : 11 October 2025
Revised : 1 May 2026
Accepted : 8 June 2026
Available Online : 18 September 2026

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ABSTRACT

Colic is a critical gastrointestinal disorder in horses, particularly in tropical environments where feed and climate stress gut health. Yeast (*Saccharomyces cerevisiae*) and coconut oil supplementation as preventive strategies against colic was evaluated in this study by modulating the gut microbiota, blood metabolites, and immune markers. A 3-period crossover design was employed using three mares (2 – 3 years old; 279 ±12 kg) across three treatments: 1) a commercial control diet (T0); 2) a yeast-supplemented diet (5 g/kg; T1); and 3) a coconut oil-supplemented diet (40 g/kg; T2). Each period included a 10-day adaptation and a 14-day treatment phase. Treatment T2 resulted in significantly higher crude fat and lower crude fiber intake ($P < 0.05$) compared to T0. Fecal analysis indicated a desirable shift in microbial profile, showing stable pH, no *Salmonella* sp. presence, and a numerical increase in lactic acid bacteria alongside a reduction in *E. coli* counts in supplemented groups. Both T1 and T2 marked a significant reduction in serum triglycerides ($P < 0.05$), with other blood parameters (glucose, protein, renal indices) remaining physiological. Hematological assessment revealed elevated neutrophil counts and neutrophil-to-lymphocyte ratios (NLR), suggesting enhanced innate immune activity and systemic stability. Collectively, these findings demonstrate that supplementing with yeast and coconut oil suggested a tendency toward microbial shifts, lipid metabolism, and immune responsiveness. The combined action of *S. cerevisiae* (promoting short-chain fatty acid production) and medium-chain fatty acids from coconut oil (providing antimicrobial and immunomodulatory benefits) strongly supports intestinal health and offers a promising, safe nutritional intervention to mitigate colic risk in horses reared in tropical settings.

Keywords: coconut oil, colic prevention, gut microbiota, horse nutrition, *Saccharomyces cerevisiae*

INTRODUCTION

Colic is one of the most common and serious gastrointestinal disorders in horses, characterized by severe abdominal pain and often leading to fatal outcomes if not managed promptly. Clinical signs include bloating, dehydration, altered bowel movements, reduced gut sounds, loss of appetite, elevated heart rate, sweating, frequent urination, congested mucous membranes, and fever (Purnama *et al.* 2021). Behavioral symptoms such as pawing, kicking, looking at the abdomen, and rolling are also indicative of abdominal discomfort (Bihonegn & Bekele 2018). Given its high mortality rate, preventive strategies are essential, with nutritional management recognized as a key approach.

Nutritional imbalances and improper feeding practices are major predisposing factors for colic. Horses require a diet high in fiber and low in starch to maintain digestive stability (Duberstein & Johnson 2009). Starch that escapes digestion in the small intestine is fermented in the hindgut, producing lactic acid and volatile fatty acids (VFAs). Accumulation of these acids lowers the pH, leading to hindgut acidosis and the proliferation of pathogenic bacteria, which can trigger endotoxemia, laminitis, and colic. Dietary additives such as probiotics and plant oils have been proposed to support microbial balance and reduce the risk of digestive disturbances.

Tropical feeding systems, such as those in Indonesia, present additional challenges for maintaining gut health in horses. Locally available feeds are typically fibrous, coarse, and variable in nutrient composition, with high moisture and rapid spoilage rates under humid conditions. These factors may lead to suboptimal fermentation, reduced nutrient utilization, and increased susceptibility to gastrointestinal disorders, including colic. Hence, strategies to enhance microbial stability and fermentation efficiency in the hindgut are particularly important for horses raised in tropical environments.

Probiotics, particularly *Saccharomyces cerevisiae* yeast, are widely used to improve digestive function and microbial balance in herbivores (Rezende *et al.* 2012). Yeast supplementation enhances cellulolytic bacterial activity, stabilizes hindgut fermentation, and promotes fiber digestion (Losada & Olleros 2002). It also supports lactate-utilizing bacteria, helping to prevent acid accumulation and maintain intestinal pH stability (Grimm *et al.* 2020).

Coconut oil is another promising dietary additive in tropical livestock feeding. It is abundant in Southeast Asia and highly digestible in the small intestine, providing a dense and efficient energy source (Wood *et al.* 2019). Having around 90% saturated fatty acids dominated by lauric acid (≈50%) coconut oil possesses antimicrobial activity against several intestinal pathogens (Silalahi & Silalahi 2022).

In this context, supplementation with yeast probiotics or coconut oil presents a novel nutritional strategy tailored for horses in tropical regions. This approach is anticipated to optimize hindgut microbial balance, enhance fiber utilization, and alleviate digestive issues linked to high-fiber tropical feeds. Accordingly, it is hypothesized that dietary inclusion of yeast and coconut oil will refine gut microbial profiles, stabilize fermentation processes, and elevate physiological and immunological parameters in horses, ultimately reducing colic risk under tropical feeding conditions.

MATERIALS AND METHODS

Ethical Approval and Study Location

This study received ethical clearance from the Animal Ethics Committee of the School of Veterinary Medicine and Biomedical Sciences, IPB University (protocol number 135/KEH/SKE/X/2023). The experiment was conducted from November 2023 to January 2024 at the Equestrian Park, IPB University, Bogor, Indonesia. The site is located in a humid tropical region with average temperatures ranging from 25 – 30°C and relative humidity exceeding 80%, conditions that may influence feed stability and microbial activity.

Animals and Experimental Design

Three clinically healthy female horses (mares), aged 2 – 3 years and averaging 279 kg body weight, were used in the study. The animals were individually housed in well-ventilated stalls equipped with feeding and drinking facilities. A 3 × 3 crossover design was employed, consisting of three treatment periods of 24 days each, including a 10-day adaptation phase followed by a 14-day treatment phase.

Table 1 Nutrient composition of control, yeast-supplemented, and coconut oil supplemented concentrate diets for horses (dry matter basis)

Nutrients	Treatments		
	T0	T1	T2
Dry matter (%)	90.4	87.4	88.6
Crude protein (% DM)	11.4	13.1	13.2
Crude fat (% DM)	3.3	3.9	8
Crude fiber (% DM)	14.5	6.6	8.2
Nitrogen-free extract (% DM)	63.3	69.9	63.7
Digestible energy (kcal/kg DM)	2,880	2,920	2,980
Total digestible nutrients (% DM)	65.4	66.1	61.6
Ash (% DM)	7.5	6.5	6.9

Notes: T0 = control diet; T1 = 5 g/kg yeast; T2 = 40 g/kg coconut oil;
Digestible Energy (DE) = [(-236+48.5)×CP)-(6.7×CF)+(37.3×NFE)+(90.1×EE)] (Núñez-Sánchez *et al.* 2019);
Total Digestible Nutrients (TDN) = (DE ÷ 0.044) (NRC 1989).

Dietary Treatments

Horses were fed four times daily, comprising two feedings of pelleted concentrate and two of forage. The experimental treatments were as follows:

- T0 (Control): Commercial concentrate.
- T1: Self-formulated concentrate + 5 g/kg yeast (*Saccharomyces cerevisiae*).
- T2: Self-formulated concentrate + 40 g/kg coconut oil.

The self-formulated concentrate was prepared using locally available ingredients wheat bran, pollard, cassava residue, corn, molasses, soybean meal, copra meal, corn gluten feed, mineral premix, calcium carbonate, and tapioca commonly used in tropical equine diets. The yeast (*Saccharomyces cerevisiae*) and coconut oil were obtained by commercial products. The nutritional composition of the experimental concentrates is presented in Table 1.

Sample Collection and Analyses

Feed Intake

Feed intake (dry matter) was calculated by subtracting the amount of feed refused from the amount of feed offered. Subsequently, nutrient intake was determined by multiplying dry matter intake by its nutrient content.

Fecal Samples

Fecal samples were collected aseptically from the rectum of horses and placed in sterile containers. Samples were weighed and diluted with buffered peptone water (BPW) at 1:10 for lactic acid bacteria, *Escherichia coli*, and *Salmonella* sp. analyses, and 1:5 for pH measurement. Lactic acid bacteria were enumerated by the Total Plate Count method at 30 °C following ISO 15214:1998 (International Organization for Standardization 1998). *E. coli* enumeration was carried out following ISO 21528-2:2004(E) (International Organization for Standardization 2004), *Salmonella* sp. detection was conducted following ISO 6579-1:2017/Amd 1:2020 (International Organization for Standardization 2020), and pH measurement was done following ISO 10390:2021 (International Organization for Standardization 2021).

Blood Samples

Jugular blood was collected into Ethylenediaminetetraacetic Acid (EDTA) tubes for hematological and biochemical analyses. Hematological parameters included red and white blood cell counts, hemoglobin concentration (Sahli method), and leukocyte differential counts from stained blood smears. Biochemical parameters were analyzed using enzymatic methods with commercial reagent kits, namely: glucose (Cat. No. 10260), triglycerides (Cat. No. 10724), total protein (Cat. No. 157004), albumin (Cat. No. 156004), blood urea nitrogen (BUN; Cat. No. 16918), and creatinine (Cat. No. 17390) form Human Gesellschaft für Biochemica und Diagnostica mbH (Wiesbaden, Germany).

Physiological Rationale for Measured Parameters

The selected indicators fecal microbial, pH, and blood metabolites provide an integrated assessment of digestive function, nutrient utilization, and physiological responses to dietary interventions. In tropical horses, where feed quality fluctuates and heat stress may alter metabolism, these parameters serve as critical markers for evaluating gut health stability and the effectiveness of nutritional strategies to prevent colic.

Statistical Analysis

A crossover design was applied with three dietary treatments and three replications. Data were analyzed using one-way analysis of variance (ANOVA). Significant differences among treatment means were determined by Duncan's multiple range test. All statistical analyses were performed using SPSS version 26 software (IBM Corp., Armonk, NY, USA). Data are expressed as means ± standard error of the mean (SEM).

RESULTS AND DISCUSSION

Nutrient Intake

The nutrient intake data presented in Table 2 show that the inclusion of yeast and coconut oil significantly increased ($P < 0.05$) crude fat intake while decreasing crude fiber intake compared to the control. No significant differences were observed in dry matter, crude protein, nitrogen-free extract, or total digestible nutrient intake.

The increase in crude fat intake observed in the T2 group corresponds to the higher lipid content of the coconut oil supplemented concentrate. Coconut oil provides medium chain triglycerides (MCTs), which are digested and absorbed efficiently in the small intestine without requiring bile salt emulsification or chylomicron formation (Huth *et al.* 2010). This rapid absorption pathway provides a readily available energy source, reducing the risk of undigested nutrients reaching the hindgut and triggering excessive fermentation a common cause of colic.

The lower fiber intake in T1 and T2 reflects the partial replacement of fibrous materials with more energy-dense ingredients. Horses require a relatively high fiber intake due to their hindgut fermentative digestive system in the cecum and colon. Therefore, the lower crude fiber intake observed in T1 and T2 may act as a potential confounding factor, influencing fermentation dynamics and microbial outcomes independently of the supplementation effects. A drastic reduction in fiber consumption may increase the risk of digestive disturbances; therefore, adequate fiber levels must be maintained in the diet (Kohnke *et al.* 1992).

While excessive fiber reduction can impair gut motility, moderate adjustments can improve energy balance, particularly in tropical climates where high temperatures may reduce feed intake. In tropical regions, forages are often coarse and high in lignin, which limits digestibility. Thus, incorporating locally available lipid sources such as coconut oil can enhance dietary energy density without relying on high-starch feeds that increase colic risk (Duberstein & Johnson 2009).

Overall, the nutrient intake results suggest that yeast and coconut oil inclusion can improve dietary energy utilization efficiency and balance fiber-to-energy ratios in horses fed tropical diets.

Table 2 Daily nutrient intake of horses fed diets containing yeast or coconut oil (dry matter basis)

Nutrients (DM basis)	Treatments			SEM	P value
	T0	T1	T2		
Dry matter (kg/head/day)	3.56	3.25	3.44	0.26	0.92
Crude protein (kg/head/day)	0.45	0.49	0.51	0.04	0.81
Crude fat (kg/head/day)	0.13b	0.15b	0.31a	0.03	0.02
Crude fiber (kg/head/day)	0.57a	0.24b	0.32b	0.06	0.02
Total digestible nutrients (kg/head/day)	2.58	2.46	2.39	0.19	0.94
Nitrogen-free extract (kg/head/day)	2.49	2.60	2.47	0.19	0.97

Notes: T0 = control diet; T1 = 5 g/kg yeast; T2 = 40 g/kg coconut oil. Different superscript in the same row indicate significant differences ($P < 0.05$).

Table 3 Fecal microbial counts and pH of horses supplemented with yeast or coconut oil

Parameters	Treatments			SEM	P value
	T0	T1	T2		
LAB (106 cfu/g)	15.3	9.2	26.3	4.72	0.37
pH	6.87	7.23	7.23	0.18	0.71
E. coli (106 cfu/g)	1.89	0.55	2.73	0.5	0.21
Salmonella sp.	0	0	0	0	0

Notes: T0 = control diet; T1 = 5 g/kg yeast; T2 = 40 g/kg coconut oil; LAB = lactic acid bacteria.

Fecal Microbial Profile and pH

Fecal microbial counts and pH data (Table 3) indicate that dietary supplementation with yeast or coconut oil did not significantly ($P > 0.05$) affect lactic acid bacteria (LAB), *Escherichia coli*, or fecal pH. However, numerical trends suggested a tendency toward increased LAB populations in T2 and reduced *E. coli* counts in T1. These findings indicate a possible shift in microbial balance, although the absence of statistical significance limits definitive conclusions.

Yeast (*Saccharomyces cerevisiae*) is known to stabilize hindgut fermentation by competing with lactic acid producing bacteria such as *Streptococcus bovis* and *Lactobacillus* while stimulating lactate utilizing bacteria including *Megasphaera elsdenii* (Amin & Mao 2021). Yeast modulates functional interactions within the hindgut microbiome, as evidenced by specific bacteria-SCFA relationships (Pombo *et al.* 2025). These microbial changes may enhance the conversion of lactic acid into short chain fatty acids (SCFAs) like propionate and butyrate, which regulate epithelial integrity, immune activation, and gut homeostasis (Wangko 2020; Le Poul *et al.* 2003). Furthermore, the concentration of acetic acid in the horse stomach increased and gas production was reduced when stomach contents were used as inoculum for in vitro fermentation (Pombo *et al.* 2024).

In tropical environments, where high humidity accelerates feed spoilage and fermentation variability, maintaining stable microbial populations is critical to prevent dysbiosis and colic. The trend toward higher fecal pH in T1 and T2 may indicate improved buffering capacity, potentially associated with enhanced lactate metabolism and more efficient fiber fermentation (Grimm *et al.* 2020). This is attributed to supplementation with *S. cerevisiae*, which promotes fibrolitic bacteria, maintains Bacteroidales populations, and reduces acidosis-causing bacteria (Carter *et al.* 2025). Similar improvements in cecal pH and reduced lactic acid accumulation were reported in yeast-supplemented horses fed high-concentrate diets (Medina *et al.* 2002; Perricone *et al.* 2022).

Coconut oil supplementation is likely to contribute through its medium-chain fatty acids, particularly lauric acid, which exhibit antimicrobial activity by selectively inhibiting pathogenic Gram-positive bacteria while sparing beneficial lactic acid bacteria (Mamman *et al.* 2005; Rolinec *et al.* 2020). Lauric acid also enhances mucosal immunity by stimulating cytokine production from macrophages and lymphocytes (Joshi *et al.* 2020). Comparable benefits of coconut oil in improving microbial balance and intestinal barrier integrity have been reported in tropical ruminants (Kusuma 2020; Rolinec *et al.* 2020).

Additionally, several mechanistic explanations presented here are derived from studies in other species, including ruminants and monogastrics. Given the physiological differences between these systems and the equine hindgut, cross-species extrapolation should be approached with caution.

Overall, the observed possible modulation, although not statistically confirmed suggests a potential benefit of dietary supplementation with yeast and coconut oil in maintaining gut balance, which is particularly advantageous for horses in tropical environments consuming high-fiber diets of variable quality.

Future studies employing high-resolution techniques such as 16S rRNA sequencing, along with larger sample sizes and longer experimental durations, are required to validate these preliminary observations.

Blood Metabolites

Blood biochemical profiles (Table 4) showed that triglyceride levels decreased significantly ($P < 0.05$) in both T1 and T2 groups, while other metabolites remained unchanged and within physiological limits.

Table 4 Blood metabolite profiles of horses fed diets supplemented with yeast or coconut oil

Blood metabolite	Treatments			SEM	P value
	T0	T1	T2		
Glucose (mg/dL)	90.84	83.47	95.08	3.73	0.5
Triglycerides (mg/dL)	32.36a	18.69b	13.21b	3.07	0.003
Total protein (mg/dL)	6.55	7.04	7.06	0.15	0.3
Albumin (mg/dL)	3.03	2.97	3.06	0.03	0.52
BUN (mg/dL)	15.01	15.55	16.20	0.86	0.89
Creatinine (mg/dL)	1.59	1.61	1.50	0.04	0.48

Notes: T0 = control diet; T1 = 5 g/kg yeast; T2 = 40 g/kg coconut oil; BUN = Blood urea nitrogen. Different superscripts in the same row indicate significant differences (P < 0.05).

The benefits of probiotics in the equine digestive tract include improved digestion, reduced allergic responses, decreased insulin resistance, enhanced lipid metabolism, and stimulation of the immune system (Li *et al.* 2025). The reduction in triglyceride levels indicates improved lipid metabolism, possibly due to SCFAs produced by microbial fermentation of indigestible carbohydrates (Ríos *et al.* 2016). SCFAs, particularly propionate, regulate hepatic lipid synthesis and promote fatty acid oxidation (He *et al.* 2021). Similarly, MCTs in coconut oil are rapidly transported via the portal. In addition, the polyphenolic compounds present in coconut oil further enhance lipid metabolism and increase plasma antioxidant capacity (Sulaiman *et al.* 2024).

Under tropical conditions, enhanced lipid metabolism is beneficial for thermoregulation and energy efficiency, as lipid oxidation produces less metabolic heat than carbohydrate fermentation. These results thus suggest that both yeast and coconut oil may support metabolic stability and lower lipid-associated colic risk in hot, humid environments.

Hematological Parameters

Hematological profiles (Table 5) showed significant increases (P < 0.05) in neutrophil percentages and neutrophil-to-lymphocyte ratio (NLR), with corresponding decreases in lymphocyte percentages in T1 and T2 groups.

Elevated neutrophil counts indicate enhanced innate immune activity (Buonacera *et al.* 2020). This may reflect immunostimulation by yeast β-glucans and mannooligosaccharides, which are known to activate macrophages and neutrophils, as demonstrated in piglets (Che *et al.* 2017). Furthermore, yeast produces a more robust and stable microbial profile in horses following a stress challenge (Ganda *et al.* 2023). Coconut oil's MCFAs also promote cytokine release and leukocyte activation (Joshi *et al.* 2020). In addition, coconut oil exerts protective effects against oxidative stress and inhibits inflammatory responses through the regulation of inflammatory mediators (Chen *et al.* 2022). In tropical horses, where heat and humidity can induce oxidative and physiological stress, enhanced innate immunity is therefore critical for maintaining resilience against gastrointestinal disturbances.

The neutrophil-to-lymphocyte ratio (NLR) is commonly used as an indicator of stress, with values greater than 1.5 generally associated with stress conditions (Kannan et al 2000), although normal ranges vary among species. In horses, the normal NLR range is reported to be 0.8 – 2.8 (Morris & Large 1990). In the present study, supplementation with yeast and coconut oil significantly increased the NLR ratio, suggesting an improvement in physiological status, as pre-treatment values were below the normal range. While elevated NLR values may suggest enhanced innate immune responsiveness, they are also widely recognized as indicators of physiological stress. In tropical environments, heat and humidity could contribute to NLR elevation independent of dietary supplementation. Future studies incorporating stress biomarkers such as cortisol would help distinguish between immune activation and stress responses.

The lack of differences in erythrocyte or hemoglobin values confirms the absence of hematotoxic effects, demonstrating that yeast and coconut oil are safe as functional additives under tropical conditions.

Table 5 Hematological profiles of horses fed control, yeast-supplemented, or coconut oil–supplemented diets

Parameters	Treatments			SEM	P value
	T0	T1	T2		
Erythrocytes (cells/mm³)	8.64	7.89	8.79	0.49	0.77
Leukocytes (cells/mm³)	8.35	8.18	7.55	0.37	0.71
Hemoglobin (%)	13.40	13.00	12.87	0.54	0.94
Lymphocytes (%)	51.50a	46.70b	48.54b	0.79	0.01
Neutrophils (%)	37.67b	43.65a	42.19a	1.07	0.03
NLR	0.73b	0.93a	0.87a	0.03	0.01
Eosinophils (%)	6.13	5.69	5.51	0.38	0.83
Monocytes (%)	3.99	3.29	3.10	0.25	0.35
Basophils (%)	0.71	0.66	0.66	0.02	0.6

Notes: T0 = control diet; T1 = 5 g/kg yeast; T2 = 40 g/kg coconut oil; NLR = neutrophil-to-lymphocyte ratio. Different superscript in the same row indicate significant differences ($P < 0.05$).

Integrated Interpretation and Tropical Relevance

Overall, dietary supplementation with *S. cerevisiae* and coconut oil improved gut microbial stability, modulated lipid metabolism, and strengthened immune responses without adverse hematological effects. These synergistic benefits are particularly relevant for horses in tropical environments, where high fiber, humid feeds can predispose animals to fermentation disorders and colic.

The integration of locally available feed additives such as yeast and coconut oil offers a practical and sustainable nutritional strategy for maintaining gut health and preventing colic in tropical horses. Future studies with longer supplementation periods and combined formulations are recommended to further elucidate their synergistic mechanisms under tropical feeding conditions.

CONCLUSION

Dietary supplementation with *Saccharomyces cerevisiae* yeast and coconut oil improved physiological and metabolic indicators associated with digestive health in horses. Both supplements enhanced lipid metabolism, stabilized gut microbial profiles, and promoted innate immune function without adverse effects on hematological parameters. These outcomes indicate that yeast and coconut oil can support gastrointestinal stability and contribute to mitigating the risk of colic, rather than serving as a direct preventive measure.

The findings are particularly significant for horses raised under tropical conditions, where high-fiber and moisture rich feeds increase the risk of fermentation imbalance and digestive disorders. The combined use of locally available yeast and coconut oil represents a sustainable nutritional approach to improve gut health and immune resilience in tropical feeding systems. However, this study has several limitations, including the small sample size and the short treatment period of only 14 days, which may limit statistical power, reduce population representativeness, and potentially obscure the full effects of the treatments. Further long-term studies involving larger populations and combined supplementation strategies are recommended to optimize their synergistic effects for equine health management in tropical environments.

ACKNOWLEDGEMENT

This research was funded by Lembaga Pengelola Dana Pendidikan (LPDP), Ministry of Finance of the Republic of Indonesia, under the RISPRO Invitasi grant (Contract No. PRJ-15/LPDP/LPDP.4/2022).

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