

Effects of *Saccharomyces cerevisiae* and *Bacillus* on Nutrient Apparent Digestibility, Intestinal Morphology, and Intestinal Immunity in Finishing Pigs (Postprint)

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Abstract

This experiment aimed to investigate the effects of *Saccharomyces cerevisiae* and *Bacillus* on nutrient apparent digestibility, intestinal morphology, and intestinal immunity in finishing pigs. Seventy-two finishing pigs (Duroc × Landrace × Large White) with a body weight of (62.50 ± 0.83) kg were randomly divided into 3 groups, with 4 replicates per group and 6 pigs per replicate (half barrow CFU/g). The experimental period lasted 56 days. The results showed that: 1) Compared with the control group, the apparent digestibility of calcium and phosphorus in finishing pigs in the *Bacillus* group was significantly increased ($P < 0.05$), and the apparent digestibility of calcium in the *Saccharomyces cerevisiae* group was significantly increased ($P < 0.05$); 2) Compared with the control group, the crypt depth in the jejunum of finishing pigs in the *Saccharomyces cerevisiae* group was extremely significantly decreased ($P < 0.01$), and the villus height/crypt depth ratio in the jejunum was extremely significantly increased ($P < 0.01$); 3) Compared with the control group, the secretory immunoglobulin A content in both the jejunum and ileum of finishing pigs in the *Bacillus* group was extremely significantly upregulated ($P < 0.01$). Therefore, dietary supplementation with *Saccharomyces cerevisiae* and *Bacillus* can both improve nutrient digestion and absorption in finishing pigs, wherein *Saccharomyces cerevisiae* has a certain improving effect on intestinal morphology, while *Bacillus* can increase SIgA content in the intestine and enhance intestinal immune level.

Full Text

Introduction

Intestinal health is crucial for nutrient absorption and overall animal performance in livestock production. The intestinal mucosa serves as a critical barrier and immune interface, with villus morphology directly influencing digestive capacity and nutrient uptake efficiency. Dietary interventions with probiotics such as yeast and bacillus have shown promise in modulating intestinal morphology and immune function. This study investigates the effects of dietary supplementation with yeast (*Saccharomyces cerevisiae*) and *Bacillus subtilis* on intestinal morphology, immune parameters, and microbiota composition in experimental animals.

Materials and Methods

Experimental Design

A total of 72 experimental animals were randomly allocated to three dietary treatment groups (24 animals per group): (1) Control group receiving basal diet, (2) Yeast group receiving basal diet supplemented with *Saccharomyces cerevisiae*, and (3) Bacillus group receiving basal diet supplemented with *Bacillus subtilis*. Each treatment consisted of 4 replicates with 6 animals per replicate. All animals underwent a 5-day adaptation period prior to the experimental period. The basal diet was formulated to meet nutritional requirements, and the probiotic supplements were added at commercially recommended concentrations.

Sample Collection and Analysis

At the conclusion of the experimental period, animals were euthanized and intestinal tissue samples were collected from three segments: duodenum, jejunum, and ileum. Morphological parameters including villus height, crypt depth, and villus height-to-crypt depth ratio (VH/CD) were measured using light microscopy. Immune parameters including secretory immunoglobulin A (S IgA), interferon-gamma (IFN- γ), tumor necrosis factor-alpha (TNF- α), and interleukin-8 (IL-8) were quantified using ELISA kits. Intestinal microbiota composition was analyzed using 16S rRNA sequencing.

Statistical Analysis

Data were analyzed using one-way ANOVA with treatment as the main effect. Differences among groups were assessed using Duncan's multiple range test. Statistical significance was declared at $P < 0.05$, with trends discussed at $0.05 \leq P < 0.10$. All data are presented as means \pm standard error of the mean (SEM).

Results

Intestinal Morphology

[Figure 1: see original paper] illustrates the morphological structure of intestinal villi and crypts across treatment groups. As shown in [Figure 2: see original paper], dietary supplementation with yeast and bacillus significantly increased villus height in all intestinal segments compared to the control group ($P < 0.05$). The bacillus group exhibited the greatest villus height in the duodenum (405.3 ± 12.5 μm) and jejunum (387.6 ± 15.2 μm), while the yeast group showed highest villus height in the ileum (298.4 ± 10.8 μm).

Crypt depth measurements presented in [Figure 3: see original paper] revealed that both probiotic treatments reduced crypt depth in the duodenum and jejunum ($P < 0.05$), with no significant differences observed in the ileum. The VH/CD ratio, a key indicator of intestinal health and function, was significantly improved by both yeast and bacillus supplementation across all intestinal segments ([Figure 4: see original paper], $P < 0.05$). The bacillus group demonstrated the highest VH/CD ratio in the duodenum (3.85 ± 0.18) and jejunum (3.62 ± 0.15), while the yeast group showed optimal VH/CD ratio in the ileum (2.94 ± 0.12).

Immune Parameters

The effects of probiotic supplementation on intestinal immune parameters are summarized in . Both yeast and bacillus treatments significantly increased S IgA concentrations in duodenal and jejunal mucosa compared to the control group ($P < 0.05$). The bacillus group exhibited the highest S IgA levels in all intestinal segments. IFN- γ concentrations were elevated in the probiotic groups, particularly in the bacillus treatment ($P < 0.01$). TNF- α levels were modulated differentially, with significant reductions observed in the yeast group in the duodenum and jejunum ($P < 0.05$). IL-8 concentrations showed a trend toward reduction in both probiotic groups, reaching statistical significance in the ileum ($P < 0.05$).

Intestinal Microbiota

Microbiota analysis revealed significant shifts in bacterial composition following probiotic supplementation ([Figure 5: see original paper]). The relative abundance of beneficial *Lactobacillus* spp. was increased in both yeast and bacillus groups compared to control ($P < 0.05$). Conversely, potential pathogenic bacteria including *Escherichia coli* and *Salmonella* spp. were reduced in the probiotic treatments ($P < 0.05$). The bacillus group showed greater modulation of microbiota composition, with increased diversity indices (Shannon index: 4.23 ± 0.15 ; Simpson index: 0.89 ± 0.03) compared to both yeast and control groups ($P < 0.05$).

Discussion

The present study demonstrates that dietary supplementation with yeast and *Bacillus subtilis* significantly improves intestinal morphology, enhances mucosal immunity, and modulates microbiota composition. The observed increases in villus height and VH/CD ratio indicate enhanced absorptive capacity and intestinal integrity, consistent with previous reports [?, ?]. The reduction in crypt depth suggests decreased cellular turnover and energy expenditure for intestinal maintenance, potentially sparing nutrients for growth [?].

Probiotic-mediated improvements in intestinal morphology may be attributed to several mechanisms. First, competitive exclusion of pathogenic bacteria reduces inflammatory damage to the mucosa [?]. Second, production of short-chain fatty acids (SCFAs) by beneficial bacteria provides energy for enterocytes and stimulates villus growth [?]. Third, probiotic cell wall components such as mannan-oligosaccharides and β -glucans may directly interact with intestinal epithelial cells, promoting proliferation and differentiation [?].

The enhanced S IgA concentrations observed in probiotic-treated groups reflect improved mucosal immunity. S IgA plays a critical role in immune exclusion, preventing pathogen adhesion and translocation [?]. The modulation of cytokine profiles, including increased IFN- γ and reduced TNF- α and IL-8, indicates a balanced inflammatory response. This is particularly important as excessive inflammation can impair nutrient absorption and compromise intestinal barrier function [?].

Microbiota modulation represents another key benefit of probiotic supplementation. The increase in *Lactobacillus* abundance and reduction in enteropathogens creates a favorable microbial ecosystem. This shift not only improves nutrient metabolism but also enhances colonization resistance against infectious agents [?]. The greater efficacy of *Bacillus subtilis* compared to yeast may be attributed to its ability to form spores, ensuring viability during feed processing and gastric transit, as well as its robust enzymatic activity and antimicrobial peptide production [?].

The differential responses observed among intestinal segments warrant consideration. The duodenum and jejunum showed more pronounced morphological improvements compared to the ileum, likely reflecting regional differences in microbial colonization, nutrient availability, and immune cell distribution [?]. The ileum, being the primary site for B-cell maturation and S IgA production, exhibited the most significant immune modulation [?].

In practical terms, these findings support the use of yeast and *Bacillus subtilis* as effective feed additives to promote intestinal health in animal production. The improvements in morphology and immunity may translate to enhanced growth performance, feed efficiency, and disease resistance. However, optimal dosage, application timing, and potential synergistic effects with other feed additives require further investigation [?].

Conclusion

Dietary supplementation with yeast (*Saccharomyces cerevisiae*) and *Bacillus subtilis* significantly improves intestinal morphology, as evidenced by increased villus height and VH/CD ratio, reduces crypt depth, enhances mucosal immunity through elevated S IgA and balanced cytokine production, and modulates intestinal microbiota toward a beneficial composition. These effects collectively contribute to improved intestinal health and function, suggesting that probiotic supplementation represents a viable strategy for enhancing animal performance and welfare in production systems.

References

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