Application of Yeast Preparations in Regulating Rumen Development and Immune Function in Calves (Postprint)

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Abstract

Yeast preparations exert certain promoting effects on balancing rumen ecology in ruminants, promoting digestive organ development, and enhancing immune function. Calves are in a special physiological stage characterized by the establishment of microecosystems, rumen structural development, and immune system maturation; yeast supplementation helps improve calf growth performance. This article summarizes previous research findings, primarily reviewing the roles of yeast preparations in calf rumen development and systemic immune function, with the aim of providing theoretical references for future scientific research and production practice.

Full Text

Application of Yeast Preparations in Regulating Rumen Development and Immune Function of Calves

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Abstract: Yeast preparations play a beneficial role in balancing rumen ecology, promoting digestive organ development, and enhancing immune function in ruminants. Calves undergo a critical physiological stage characterized by the establishment of microecosystems, rumen structural development, and immune system maturation, during which yeast supplementation can improve growth performance. This review synthesizes previous research findings on the effects of yeast preparations on rumen development and immune function in calves, aiming to provide theoretical references for future research and production practice.

Keywords: yeast preparation; calves; rumen development; immune function

1 Classification and Effects of Yeast Preparations

To date, over 1,000 yeast species have been identified, forming an extensive family with widespread applications in healthcare, brewing, food processing, pigment production, and animal husbandry. In livestock production, yeast preparations are broadly classified into two categories. The first is bioactive yeast, derived from dried fermented live yeast containing at least 1.5×10 viable yeast cells per gram, which improves gastrointestinal microecological balance and acts as a probiotic for ruminants. The second is yeast culture, produced by drying yeast together with its growth medium, which contains yeast cell wall components (-glucans and mannans), soluble vitamins, proteins, peptides, amino acids, nucleotides, lipids, organic acids, esters, alcohols, B vitamins, polyphenols, and antioxidants [2-3]. These compounds collectively promote animal growth and health, leading some researchers to attribute the efficacy of yeast preparations primarily to cell wall constituents. Yeast culture contains few live yeast cells but abundant metabolites, suggesting it may exert both probiotic and prebiotic effects, though recent studies indicate no significant difference between these two product types in modulating rumen fermentation [2].

2.1 Effects on Rumen Morphological Development in Calves

Gastrointestinal development is crucial for calf growth and health, depending primarily on microbial colonization, initial fiber consumption, and digestive mechanisms [4]. Due to their small rumen volume and underdeveloped rumen function, calves functionally resemble monogastric animals. Rumen function depends on structural development, and dietary supplementation with microbial preparations can accelerate changes in gastrointestinal parameters [5]. Rumen fermentation capacity correlates with villus morphology, and yeast culture has been shown to improve the crypt depth-to-villus height ratio [6]. Lesmeister et al. [7] reported that supplementing 2% yeast culture during weaning increased rumen villus length and width by 19% and 21%, respectively. Brewer et al. [8] similarly demonstrated that yeast culture promoted rumen villus maturation in underweight calves. However, Kaldmäe et al. [9] found no significant effects on villus length, width, quantity, or rumen wall thickness, possibly due to differences in calf age, as villus development patterns change with animal growth. The observable effects of yeast preparations also depend on administration route; effects are only evident when yeast enters the rumen with feed, not when it bypasses the rumen with milk and enters the abomasum [10].

2.2 Effects on Rumen Microecological Development in Calves

Microorganisms form the foundation of rumen function, with colonization beginning at birth. Critically important rumen bacteria appear in the rumen immediately after birth [11]. Yeast preparations can accelerate the establishment of rumen microbial communities, which is essential for achieving functional rumen ecosystems during weaning. During the first 28 days of life, active dry yeast increases the abundance of *Butyrivibrio* species and elevates butyrate concentration [12]. Supplementing heifer diets with yeast culture increases total rumen bacterial counts [13], particularly under high-fiber conditions [3]. In vitro studies also show that yeast culture increases total numbers of bacteria, fungi, and protozoa in artificial rumen systems [14], indicating it promotes fiber-degrading bacterial proliferation and prepares calves for fiber-based diets. Yeast culture particularly enhances lactate-utilizing bacteria [3]; lactate consumption not only reduces product concentration to facilitate further substrate degradation but also mitigates pH decline, minimizing harm to the animal and microbial ecosystem from acidic conditions. The mechanism by which active yeast modulates rumen ecology may involve oxygen consumption, competition with harmful bacteria for substrates and niche space, and provision of nutrients for beneficial bacteria while metabolizing their byproducts, though specific regulatory mechanisms require further investigation.

2.3 Effects on Rumen Internal Environment Development in Calves

Stable rumen pH provides a suitable environment for bacterial and protozoal survival [15]. While yeast preparations are recognized for stabilizing rumen pH through lactate control, their effects on volatile fatty acids (VFAs) remain unclear. Some researchers suggest active yeast shifts fiber-degrading bacterial metabolism to reduce total VFA concentration while increasing propionate proportion [16]. Conversely, Mutsvangwa et al. [17] found that feeding active yeast to 3-month-old calves increased acetate and total VFA concentrations. These divergent findings may reflect yeast' s greater reliance on lactate regulation rather than VFA modulation for pH stabilization. Anaerobic conditions are also critical for rumen fermentation function. Newbold [18] reported that yeast promotes anaerobic fungal growth, increasing oxygen disappearance rates by 46-89% and thereby reinforcing the anaerobic environment essential for fungal survival.

3.1 Effects on Immune Function in Calves

The intestine serves as the first line of defense against pathogens and harmful substances [19] and represents the primary site where yeast preparations exert immunomodulatory effects. Yeast culture provides bioactive compounds with anti-inflammatory, antioxidant, and immune-regulating properties [20]. Complex polysaccharides in yeast cell walls, particularly -glucans and mannans, have confirmed immunomodulatory functions [2]. Yeast-derived -glucans are recognized as pathogen-associated molecular patterns (PAMPs) by pattern recognition receptors (PRRs), facilitating antigen recognition by antibodies [21]. Since animals cannot synthesize these components themselves, innate immune cells such as neutrophils and macrophages rely on them for pathogen identification [21]. Because yeast cannot penetrate intestinal epithelial barriers, researchers propose that -glucans mediate the immunomodulatory effects [22], suggesting that yeast enhances calf immunity not only by providing immune-active substances but primarily by improving innate immune cell pathogen recognition capacity.

3.2 Effects on Initiating Adaptive Immunity in Calves

Endotoxin challenge in calves alters blood parameters and behaviors including feeding, lying, grooming, and rumination [23]. Yeast culture supplementation enables rapid recovery from toxin effects [24] by activating adaptive immune responses, during which immune-active substances proliferate until reaching a critical threshold capable of combating infectious pathogens. This process establishes a feedback "inhibition" mechanism that ensures host resistance to inflammation without over-stimulating or suppressing immune activity [25]. For pre-ruminant calves, immune capacity depends heavily on nutrient intake since some immune-active substances are obtained from maternal milk. Researchers suggest that improving nutrient supply is more fundamental for enhancing calf health than modifying immune system components [26-27]. Yeast culture provides not only abundant nutrients but also immune-active substances and regulatory factors, making it crucial for healthy calf growth.

3.3 Effects on Resistance to Pathogenic Microorganisms in Calves

Due to their immature immune systems, calves are highly susceptible to pathogenic microorganisms and environmental stress. Fever and diarrhea are common symptoms that result in low weaning weights and poor post-weaning growth that cannot be compensated by later nutrition [28]. Calf diarrhea correlates with microbial diversity [29]; stable microbial systems help resist infection. When pathogenic bacteria proliferate in the small intestine, microbial diversity is disrupted, reducing beneficial symbiotic bacteria [30]. Yeast culture promotes colonization and proliferation of beneficial symbionts [8], competing with pathogens for space and nutrients, which may explain its pathogen control effects. Studies show yeast culture increases microbial species richness in the large intestine, promotes fiber-degrading bacterial colonization, and reduces diarrhea incidence [6,31]. Brewer et al. [8] demonstrated that *Saccharomyces cerevisiae* fermentation products (SCFP) ameliorated salmonellosis, with few SCFP-treated calves developing diarrhea or fever while control calves continued showing symptoms four days post-treatment. Galvão et al. [32] found yeast preparations reduced diarrhea duration without affecting fecal scores, indicating they can stimulate beneficial bacteria while inhibiting harmful bacteria within certain limits.

3.4 Effects on Other Pathological Factors

The immune and antioxidant systems are interrelated. In vitro studies show low-concentration yeast culture (0.0001 mg/L) significantly reduces reactive oxygen species formation in neutrophils [2], creating favorable conditions for immune function. Diarrhea is closely associated with electrolyte loss, and yeast culture reduces electrolyte utilization in calves [31,33], helping mitigate diarrhea. Fever is another important pathological manifestation. Hill et al. [10] observed a trend toward reduced body temperature in calves supplemented with active yeast, while Seymour et al. [34] reported significant temperature reduction following yeast culture supplementation, demonstrating yeast preparations' fever-alleviating effects.

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5 Summary and Outlook

Yeast preparations improve rumen structural parameters, balance rumen microbial communities, and enhance immune function in calves, with potentially greater effects under stress conditions. Yeast culture and active dry yeast show similar efficacy in regulating rumen microecology and fermentation, though reports on active yeast' s immune-enhancing effects are limited compared to the more prominent effects of yeast culture. Importantly, yeast preparations are safe, non-toxic, and residue-free, making them excellent antibiotic alternatives for calf feed additives. However, further research efforts are needed to optimize application effects.

Calves lack developed rumen structures and stable rumen ecosystems, and microbial colonization forms the basis of rumen development and function. Future studies should employ real-time quantitative PCR, high-throughput sequencing, and metagenomics to monitor microbial populations affected by yeast preparations, which would better elucidate regulatory mechanisms. Continued investigation of yeast preparations' effects on rumen development is crucial, as healthy rumens improve animal health and later production performance. Monitoring rumen structural parameters from birth may be particularly effective due to rapid developmental changes during this period. Additionally, future experiments should incorporate more control variables such as age, sex, breed, and environmental conditions to systematically study yeast effects. Research on yeast preparations' mechanisms for reducing electrolyte loss should be deepened, as this may clarify the direct cause of reduced diarrhea and improve efficacy. Although yeast mechanisms remain incompletely understood, their effects clearly depend on nutritional, immunological, and microecological regulation. Future research advancing these three aspects will likely yield substantial progress.

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