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ROLE OF EUBIOTICS IN ANIMAL HEALTH AND PERFORMANCE: A REVIEW

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Abstract

The escalating restrictions on antibiotic growth promoters (AGPs) in livestock production have catalyzed the search for sustainable alternatives to safeguard animal health and productivity. Eubiotics - a comprehensive category of feed additives encompassing probiotics, prebiotics, synbiotics, organic acids, phytogenic compounds, enzymes, and postbiotics -have emerged as potent tools for enhancing gastrointestinal health, nutrient utilization, immune competence, and zootechnical performance. This review synthesizes current knowledge regarding the mechanisms of action, applications, and systemic benefits of eubiotics in animal nutrition. A structured literature review (2018–2025) was conducted across major databases, including PubMed, Web of Science, Scopus, and ScienceDirect. Evidence indicates that eubiotics maintain intestinal homeostasis by modulating microbial populations, reinforcing gut barrier integrity, and mitigating pathogen colonization. While numerous studies report significant improvements in growth rates, feed conversion ratios (FCR), and animal welfare, inconsistencies persist due to variations in experimental design, dosage, and environmental factors. Further research is imperative to standardize methodologies and elucidate the complex interactions between eubiotics, host physiology, and the microbiome.

Key words: *eubiotics, gut microbiota, animal health, feed additive, performance.*

INTRODUCTION

The surging global demand for animal-derived proteins has intensified the shift toward sustainable production systems that prioritize animal welfare and productivity while minimizing environmental footprints. For decades, antibiotic growth promoters (AGPs) were foundational in livestock production for enhancing performance and controlling subclinical infections. However, the rise of antimicrobial resistance (AMR) has triggered global legislative bans on routine antibiotic use in feed (Alayande et al., 2020; Chowdhury et al., 2025). Consequently, scientific inquiry has shifted toward identifying nutritional strategies that sustain performance without reliance on traditional antimicrobials.

Among the most promising alternatives are eubiotics, a diverse group of feed additives designed to foster microbial symbiosis and gastrointestinal resilience (Jha et al., 2021; Yue et al., 2025). The term "eubiotic" originates from the Greek words “eu” (good) and “bios” (life) and refers to substances that contribute to the maintenance of microbial homeostasis. Eubiotics include a broad spectrum of functional additives, from probiotics and prebiotics to more recent innovations such as postbiotics and phytogenics (Broom, 2022; Azad et al., 2020).

The gastrointestinal tract (GIT) plays a central role in animal performance; beyond its digestive function, it serves as the primary immunological interface between the host and its environment. A balanced microbiota is essential for nutrient metabolism, pathogen exclusion, and epithelial integrity. Conversely, dysbiosis - the disruption of this microbial balance - impairs nutrient absorption and increases susceptibility to disease. Recent advances in metagenomics have highlighted how eubiotics influence these pathways by modulating microbial diversity and improving gut integrity (Cho et al., 2024; Śliżewska et al., 2020).

The application of eubiotics has been extensively investigated in poultry, swine, ruminants, and aquaculture systems. Improvements in growth performance, feed efficiency, nutrient digestibility, and disease resistance have been widely documented (Krysiak et al., 2021; Liao & Nyachoti, 2022; Gheorghe-Irimia et al., 2023). In addition,

eubiotics contribute to mitigating pathogen shedding and improving food safety (Abdel-Latif et al., 2018; Abdel-Wareth et al., 2019).

Despite the growing body of evidence, several challenges remain. The efficacy of these additives is subject to variables such as physiological stage, dietary matrix, and management practices. Furthermore, the mechanisms underlying the interactions between eubiotics and host metabolism are not yet fully elucidated (Duarte et al., 2020; Elghandour et al., 2022). This review aims to summarize the current state of knowledge regarding eubiotics, focusing on their mechanisms of action and their role in optimizing performance in modern livestock systems.

MATERIALS AND METHODS

Study Design

This study was conducted as a narrative review based on a structured search strategy and a qualitative synthesis of peer-reviewed evidence. The scope encompassed the effects of various eubiotics (probiotics, prebiotics, organic acids, enzymes, etc.) on gut modulation, nutrient utilization, and productive performance across major livestock species (Nguyen et al., 2020; Jha et al., 2021).

Data Sources and Search Strategy

A comprehensive search was performed using PubMed, Web of Science, Scopus, and ScienceDirect, supplemented by Google Scholar for citation verification. Search strings utilized Boolean operators (AND, OR) and focused on terms such as “eubiotics”, “gut microbiota”, “livestock performance”, and “feed additives”. The temporal scope was restricted to 2018-2025 to ensure an up-to-date perspective.

Inclusion and Exclusion Criteria

Primary research and systematic reviews published in English within the specified timeframe were included. Criteria required studies to provide clear methodological frameworks and report outcomes related to intestinal health or zootechnical parameters. Studies on probiotics, prebiotics, synbiotics, organic acids, and enzyme-based additives were prioritized (Azad et al., 2020; Chukwudi et al., 2024). Excluded were studies focusing on human nutrition, non-peer-reviewed editorials, and conference abstracts lacking full-text data.

Data extraction focused on species-specific responses, dosage strategies, and mechanisms of action related to gut microbiota modulation and performance outcomes.

RESULTS AND DISCUSSIONS

Types of Eubiotics and Their Mechanisms of Action

Eubiotics encompass a diverse array of additives with the shared goal of optimizing gastrointestinal homeostasis.

Probiotics, including Lactobacillus, Bacillus, and yeast strains, enhance microbial balance through competitive exclusion and antimicrobial metabolite production (Krysiak et al., 2021; Liao & Nyachoti, 2022).

Prebiotics such as fructo-oligosaccharides and mannan-oligosaccharides selectively stimulate beneficial bacteria, increasing short-chain fatty acid production and improving gut energy metabolism (Azad et al., 2020; Broom, 2022).

Synbiotics, combining probiotics and prebiotics, exert synergistic effects that enhance microbial colonization and intestinal health (Duarte et al., 2020; Shah et al., 2023).

Organic acids such as butyric and citric acid reduce intestinal pH and inhibit pathogenic bacteria, improving enzymatic activity and nutrient digestibility (Nguyen et al., 2020; Chukwudi et al., 2024).

Postbiotics and enzyme-based additives improve gut functionality through direct modulation of immune responses and nutrient availability (Elghandour et al., 2022; Cho et al., 2024).

Effects on Gut Microbiota and Intestinal Health

Modulation of the gut microbiome is a central mechanism of eubiotic action. Supplementation consistently increases beneficial bacterial populations while reducing pathogens such as Escherichia coli and Salmonella spp. (Śliżewska et al., 2020; Abdel-Latif et al., 2023, Șonea et al., 2024).

Eubiotics also improve intestinal morphology, increasing villus height and villus-to-crypt ratio, thereby enhancing nutrient absorption capacity (Cho et al., 2024; Abdel-Wareth et al., 2019).

Nutrient Digestibility and Feed Efficiency

Organic acids improve enzymatic digestion and nutrient absorption efficiency, while exogenous enzymes enhance degradation of anti-nutritional factors (Nguyen et al., 2020; Elghandour et al., 2022).

Integrated strategies combining probiotics, prebiotics, and enzymes show the most consistent improvements in feed conversion ratio and nutrient retention (Jha et al., 2021; Maina et al., 2022).

Immunomodulatory and Performance Outcomes

The gastrointestinal tract contains a major portion of the immune system, and eubiotics enhance immune regulation by strengthening epithelial barriers and modulating cytokine expression (Duarte et al., 2020; Chowdhury et al., 2025).

These effects translate into improved growth performance, feed efficiency, and disease resistance in poultry, swine, and ruminants (Abd El-Latif & Omar, 2023; Murshed et al., 2023; Șonea et al.,2023).

Current Challenges and Knowledge Gaps

Despite strong evidence, variability in outcomes remains due to differences in species, diet composition, and environmental conditions (Alayande et al., 2020; Yue et al., 2025, Gheorghe-Irimia et al., 2024).

The mechanisms governing host-microbiota-eubiotic interactions are still not fully understood, and further omics-based approaches are needed to standardize dosage and optimize combinations (Elghandour et al., 2022; Chowdhury et al., 2025).

CONCLUSIONS

Collectively, the available evidence supports the use of eubiotics as promising nutritional strategies for enhancing gut health, strengthening host resilience, and improving productive outcomes in livestock species. Probiotics, prebiotics, synbiotics, organic acids, enzymes, and postbiotics contribute to the maintenance of gastrointestinal homeostasis through modulation of gut microbiota, enhancement of intestinal barrier integrity, stimulation of immune responses, and improvement of nutrient utilization.

Numerous studies have reported positive effects of eubiotic supplementation on growth performance, feed efficiency, disease resistance, and animal welfare. Improvements in intestinal morphology, beneficial microbial populations, and digestive efficiency appear to be among the most consistent findings across poultry, swine, and ruminant production systems. In addition, growing evidence supports the use of eubiotics as sustainable alternatives to antibiotic growth promoters, contributing to efforts aimed at reducing antimicrobial resistance in animal agriculture.

Despite these benefits, the efficacy of eubiotics may vary according to animal species, physiological stage, dietary composition, environmental conditions, and the specific additives used. Differences in experimental methodologies and supplementation protocols continue to limit direct comparisons among studies.

Future research should focus on the development of standardized evaluation protocols, identification of optimal combinations of eubiotic compounds, and a deeper understanding of host–microbiota interactions using modern molecular and microbiome-based approaches. Further investigation is also required to assess the long-term economic and health impacts of eubiotic supplementation under commercial production conditions.

Overall, eubiotics represent a promising and scientifically supported strategy for promoting sustainable livestock production by simultaneously improving animal health, productivity, and food production efficiency while reducing dependence on antibiotic growth promoters.

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