Scientia Review, Vol. 01(04), October 2025, pp. 19-20

Scientia Review

Website: www.scientiafoundation.in

POPULAR SCIENCE ARTICLE

Role of Probiotics and Prebiotics in Aquaculture Health Management

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Received: 17 September 2025
Revised: 25 September 2025
Accepted: 27 September 2025
Published online: 17 October 2025

Article ID: SR01036

Citation: Saikia, N. (2025). Role of Probiotics and Prebiotics in Aquaculture Health Management. *Scientia Review*, 1(4), 19-20

Abstract

The increasing demand for sustainable aquaculture has necessitated the exploration of alternative health management strategies to reduce dependency on antibiotics. Probiotics and prebiotics have emerged as promising biological interventions to enhance fish growth, immunity and disease resistance. Probiotics, comprising beneficial live microorganisms, modulate gut microbiota and improve nutrient absorption, whereas prebiotics, non-digestible food ingredients, selectively stimulate the growth of beneficial microbes. The integration of these functional additives in aquaculture systems offers a potential solution to improve fish health, minimize environmental impact and ensure sustainable production.

Keywords: Probiotics, Prebiotics, Aquaculture, Fish health, Immunity, Disease management

Introduction

Aquaculture has become a critical component of global food security, contributing significantly to the supply of high-quality protein. However, intensification of aquaculture practices has led to increased disease outbreaks, resulting in significant economic losses (FAO, 2018). Traditionally, antibiotics have been used to mitigate these challenges, but their excessive use has raised concerns regarding antimicrobial resistance and environmental contamination (Cabello *et al*., 2016). Consequently, there is growing interest in sustainable alternatives such as probiotics and prebiotics, which offer health-promoting effects without the negative consequences associated with chemical treatments.

Probiotics are defined as live microorganisms which, when administered in adequate amounts, confer health benefits to the host (Hotel & Cordoba, 2001). They play a pivotal role in maintaining intestinal microbial balance, enhancing digestion, stimulating the immune system and providing resistance against pathogenic bacteria (Gatesoupe, 1999). Prebiotics, on the other hand, are non-digestible dietary components that selectively promote the growth and activity of beneficial gut microbiota, indirectly contributing to host health (Gibson & Roberfroid, 1995). The combined use of probiotics and prebiotics, termed synbiotics, has been explored as a synergistic strategy for improving aquaculture health management.

Mechanisms of Action

Probiotics exert their beneficial effects through multiple mechanisms. They compete with pathogens for adhesion sites in the gut, secrete antimicrobial substances such as bacteriocins, modulate immune responses and enhance enzymatic digestion (Verschuere *et al.*, 2000). Common probiotic strains in aquaculture include *Lactobacillus*, *Bacillus*, *Enterococcus* and *Saccharomyces* species (Nayak, 2010). Prebiotics, such as fructooligosaccharides (FOS), inulin and mannanoligosaccharides (MOS), act as selective substrates for beneficial microbes, leading to increased production of short-chain fatty acids, which promote gut health and systemic immunity (Ringø *et al.*, 2010).

Effects on Fish Growth and Nutrient Utilization

Immune Modulation and Disease Resistance

Probiotics enhance innate and adaptive immune responses in fish by stimulating phagocytosis, lysozyme activity, complement system and production of immunoglobulins (Gatesoupe, 1999). Prebiotics similarly improve immune function by modulating gut microbiota, leading to the production of bioactive metabolites that interact with immune cells (Li *et al.*, 2007). Combined

administration as synbiotics has shown synergistic effects, providing stronger protection against bacterial and viral infections (Gomez-Gil *et al*., 2000).

Environmental and Economic Benefits

Use of probiotics and prebiotics reduces reliance on antibiotics, mitigating antimicrobial resistance risks and minimizing water pollution due to chemical residues (Cabello *et al*., 2016). Enhanced growth and feed efficiency translate to lower feed costs and increased profitability. Additionally, healthier fish populations reduce losses from disease outbreaks, promoting sustainable aquaculture practices (Verschuere *et al.*, 2000).

Challenges and Future Prospects

Despite their benefits, practical challenges exist in the commercial application of probiotics and prebiotics, including strain selection, stability during feed processing, optimal dosing and regulatory approvals (Hai, 2015). Future research should focus on identifying novel strains, understanding host-microbe interactions at the molecular level and developing cost-effective delivery methods. Integration with precision aquaculture technologies can further optimize their application for improved fish health management.

Conclusion

Probiotics and prebiotics represent a sustainable and effective approach for enhancing aquaculture health management. Their ability to improve growth, immune function and disease resistance makes them a viable alternative to antibiotics. Adoption of these functional feed additives not only ensures healthier fish stocks but also contributes to environmental conservation and economic sustainability. Continued research, combined with field-level application strategies, is essential for maximizing their potential in modern aquaculture systems.

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