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Probiotics in Aquaculture: A Safer Alternative to Antibiotics

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Aquaculture is a rapidly expanding sector essential for global food security, yet disease outbreaks and excessive antibiotic use pose significant challenges. The overuse of antibiotics has led to antimicrobial resistance, environmental contamination, and potential risks to human health. In this context, probiotics have emerged as a sustainable and eco-friendly alternative. They improve growth performance, enhance immune responses, promote gut health, and contribute to better water quality through microbial balance and bioremediation. Probiotics act via mechanisms such as competitive exclusion, antimicrobial production, and immune stimulation. Despite challenges like strain specificity and variable efficacy, probiotics offer a promising strategy to reduce antibiotic dependence and support sustainable aquaculture practices.

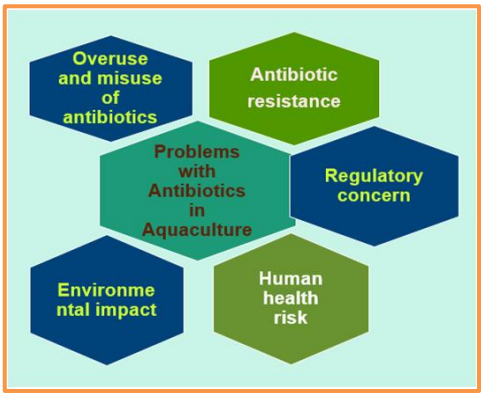
Keywords: Probiotics, Aquaculture, Antimicrobial Resistance, Fish Health, Sustainable Farming

Introduction

Aquaculture is one of the fastest growing sectors globally. It plays a crucial role in food security. The rapid intensification of aquaculture increases the likelihood of disease incidence in culture systems (Rahayu et al., 2024). Initially, antibiotics were used to control bacterial diseases in the culture system, but their excessive use leads to antimicrobial resistance (AMR); such resistance is becoming a serious threat to the aquatic ecosystem (Mohammed et al., 2025). Along with this, accumulation of antibiotic residues in water bodies is disturbing the ecological balance (Calcagnile et al., 2024). In this context, probiotics have emerged as an eco-friendly alternative to inhibit pathogenic microorganisms. These probiotics have other advantages also, like enhanced immune response and improved growth performance in culture systems (Elsegeny et al., 2025; Ghosh et al., 2025). Thus, the application of probiotics represents a sustainable strategy to reduce antibiotic dependence and promote healthier aquaculture systems.

Problems with Antibiotics in Aquaculture

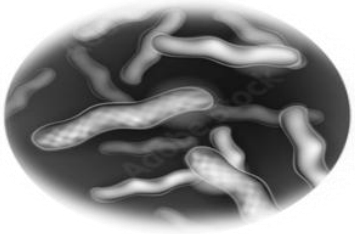
1. In intensive aquaculture, antibiotics are widely used to control diseases without knowing the proper dosage or their use.
2. This continued exposure to antibiotics leads to the development of antibiotic-resistant bacteria. These bacteria are very resistant to antibiotics and very difficult to control.
3. These antibiotic residues used in the culture system can enter the ecosystem unknowingly and disrupt the balance between microbial communities and the ecosystem. Sometimes these bacteria can affect the non-target aquatic organisms.



4. Antibiotic residues can enter the human food chain through the consumption of fish and reduce the effectiveness of antibiotics in human medicine.
5. Global markets require antibiotic residue-free aquaculture products.

What Are Probiotics?

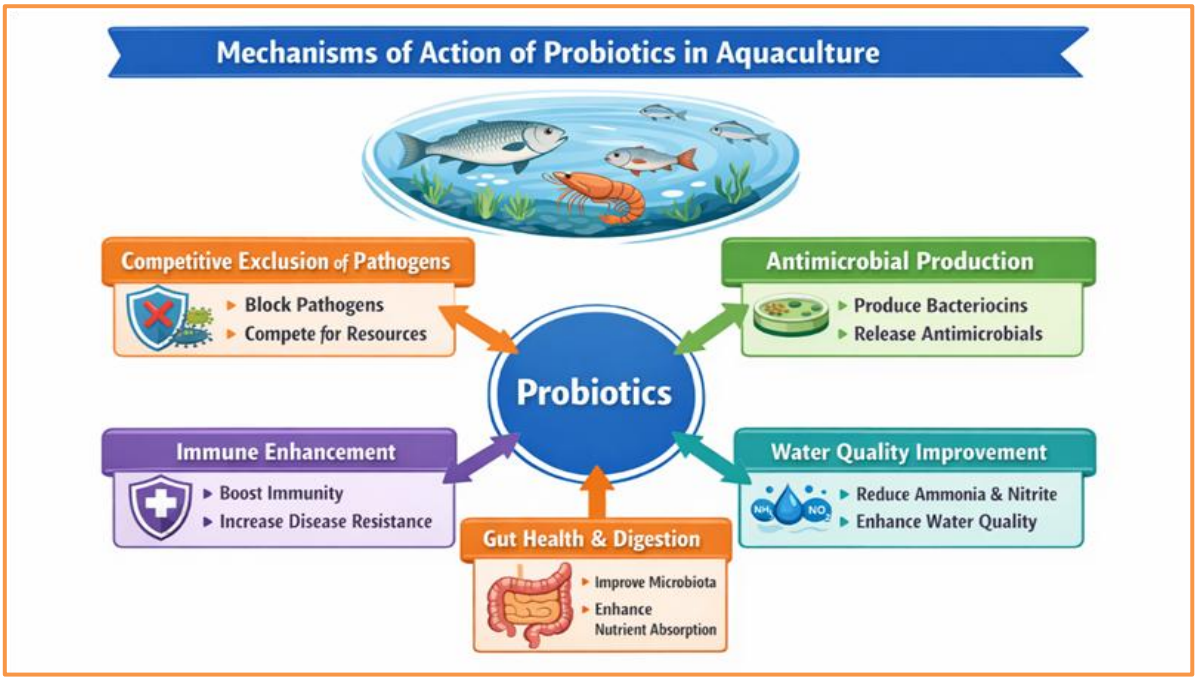
According to the Food and Agriculture Organization and the World Health Organization, Probiotics are live bacteria that, when administered in enough amounts, improve the host's health. In aquaculture, probiotics play an important role in improving growth performance, enhancing immune response, increasing stress tolerance, and providing resistance against diseases. Commonly used probiotic groups include

		
***Bacillus* sp.**	***Lactobacillus* sp.**	***Saccharomyces* sp**

- ***Bacillus* species**, known for their stability and ability to improve digestion and water quality.
- ***Lactobacillus* species**, which promote gut health and produce antimicrobial substances.
- ***Saccharomyces* species**, which enhance nutrient absorption and immunity.

Other probiotics used in aquaculture are *Pseudomonas*, *Enterococcus*, *Streptococcus*, *Clostridium*, *Bifidobacterium*, *Nitrosomonas*, *Nitrobacter*, *Rhodobacter* and etc..,. These probiotics are obtained from natural sources such as aquatic environments and the gut microbiota of healthy organisms, as well as from commercially developed formulations and laboratory-isolated strains.

Mechanisms of Action of Probiotics in Aquaculture



1. Competitive exclusion of pathogens: Probiotics inhibit pathogenic microorganisms by competing with them for nutrients, adhesion sites, and space in the gut and surrounding environment. This prevents harmful bacteria from colonizing the host and reduces disease outbreaks in aquaculture systems (Calcagnile et al., 2024).

2. Production of antimicrobial substances: Many probiotic strains produce bioactive compounds such as bacteriocins, organic acids, hydrogen peroxide, and enzymes that directly suppress or kill pathogens. These antimicrobial metabolites play a crucial role in maintaining microbial balance and protecting aquatic organisms from infections

3. Enhancement of immune response: Probiotics stimulate both innate and adaptive immunity by increasing immune-related enzymes, cytokines, and complement proteins. They enhance disease resistance by activating immune pathways and strengthening the host defence system against pathogens

4. Improvement of gut health and digestion: Probiotics help maintain a balanced intestinal microbiota, improve gut integrity, and increase digestive enzyme activity. This leads to better nutrient absorption, feed utilization, and overall growth performance in aquatic species

5. Water quality improvement: Certain probiotics contribute to bioremediation by reducing harmful metabolites such as ammonia and nitrite through nitrification and denitrification processes. They also regulate microbial communities in the water, thereby improving overall water quality and reducing environmental stress

Applications of Probiotics in Aquaculture

Probiotics have diverse applications in aquaculture, contributing to improved health, growth, and sustainability of cultured species.

- In fish culture, probiotics are commonly used to enhance growth performance, feed utilization, and disease resistance by improving gut microbiota and stimulating immune responses.
- In shrimp farming, they play a crucial role in increasing survival rates, promoting better nutrient absorption, and reducing the impact of pathogenic microorganisms, thereby improving overall production efficiency.
- Probiotics are also essential in larval rearing systems, where they help stabilize microbial communities, improve water quality, and enhance larval survival and development.
- Additionally, probiotics can be applied either through feed supplementation or directly into water. Feed-based application mainly improves digestion, nutrient absorption, and immunity, while water application helps maintain environmental quality by controlling harmful microbes. A combined approach of both methods is often considered most effective for achieving optimal results in aquaculture systems, ensuring better productivity and sustainability.

Challenges and Limitations of Probiotics in Aquaculture

Probiotics offer many benefits in aquaculture, but their effectiveness is often inconsistent due to several challenges.

- One major limitation is the variability in results, as their performance can differ depending on environmental conditions, host species, dosage, and farming practices.
- Additionally, probiotic effects are highly strain-specific, meaning that not all strains of the same microbial group produce the same benefits, making selection and application more complex.
- Storage and shelf-life issues also pose significant challenges, as probiotics are live microorganisms that can lose viability during processing, transport, and storage, especially under unfavorable conditions.

Furthermore, there is a growing need for proper standardization and regulation, as the lack of uniform guidelines for probiotic formulation, dosage, and quality control can lead to inconsistent outcomes and reduced farmer confidence. Addressing these limitations is essential to ensure the reliable and effective use of probiotics in sustainable aquaculture practices.

Conclusion

Probiotics have emerged as a safer and eco-friendly alternative to antibiotics in aquaculture, offering an effective approach to disease control without contributing to antimicrobial

resistance. Their ability to enhance growth, improve immunity, and maintain water quality highlights their importance in modern aquaculture practices. Moreover, probiotics support sustainability by promoting healthier culture systems, reducing environmental impacts, and improving long-term productivity. Despite some challenges, their overall benefits make them a promising tool for achieving responsible and profitable aquaculture. Therefore, wider adoption of probiotics by farmers and stakeholders is strongly recommended. At the same time, further research is essential to optimize strain selection, application methods, and regulatory frameworks, ensuring consistent results and maximizing their potential in sustainable aquaculture development.

References

1. Mohammed, E.A.H., Ahmed, A.E.M., Kovács, B. and Pál, K., 2025. The significance of probiotics in aquaculture: a review of research trend and latest scientific findings. *Antibiotics*, *14*(3), p.242.
2. Elsegeny, S.R., Radwan, F.S., Elshamy, Y.M., Amer, S.M., Mohamed, R.A., Shokrak, N.M. and Abdella, B., 2025. A comprehensive overview of probiotics in aquaculture: from efficacy evaluation to diverse applications. *Annals of Microbiology*, *75*(1), p.35.
3. Rahayu, S., Amoah, K., Huang, Y., Cai, J., Wang, B., Shija, V.M., Jin, X., Anokyewaa, M.A. and Jiang, M., 2024. Probiotics application in aquaculture: its potential effects, current status in China and future prospects. *Frontiers in Marine Science*, *11*, p.1455905.
4. Calcagnile, M., Tredici, S.M. and Alifano, P., 2024. A comprehensive review on probiotics and their use in aquaculture: Biological control, efficacy, and safety through the genomics and wet methods. *Heliyon*, *10*(24).