Probiotics and Prebiotics in Aquaculture: Emerging Tools for Improved Fish Health Management

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ABSTRACT

Aquaculture is one of the fastest-growing sectors of food production worldwide, playing a vital role in fulfilling the increasing demand for aquatic protein production. However, infectious diseases remain one of the major concerns for the sustainability of aquaculture production. Conventionally, antibiotics and chemotherapeutics have been used for the control of infectious diseases in cultured aquatic animals. The overuse of antibiotics has led to serious concerns, such as the emergence of antibiotic resistance, environmental contamination, and the presence of residues of antibiotics in fish products. Hence, the use of sustainable and eco-friendly alternatives for the management of infectious diseases has become essential. Probiotics and prebiotics have become important feed additives for improving fish health and production. Probiotics are live microorganisms, which, when administered in sufficient amounts, provide health benefits for the host, while prebiotics are nondigestible components of feed that promote the growth of beneficial microflora in the gastrointestinal tract of animals. Probiotics and prebiotics, as microbial feed additives, have been found to be effective for improving the health of farmed fish. Hence, the use of

probiotics and prebiotics can be used as sustainable alternatives for improving the health of farmed fish.

INTRODUCTION

In the last few decades, the growth of aquaculture has been impressive, and it has turned out to be one of the most significant contributors to food production globally. Due to the growing demand for fish and fishery products, the level of aquaculture production has risen significantly to compensate for the reduction in fish stocks in the wild. The aquaculture industry is a vital source of animal protein and a livelihood source for millions of people around the world (Mugwanya *et al*., 2022). However, despite the rapid development of the aquaculture industry, it has been facing many challenges that affect the productivity of the industry significantly. Among the many challenges faced by the industry, it has been identified that the impact of infectious diseases is one of the most significant challenges faced by the industry. The factors that affect the immune system of fish and make them susceptible to infections include the presence of high stocking density, poor water quality, environmental factors, and nutritional factors. Traditionally, antibiotics and chemotherapeutic agents have been extensively used in aquaculture systems to prevent bacterial diseases.

However, the improper and excessive use of antibiotics has resulted in the emergence of antibiotic-resistant bacteria and contamination of the environment. In addition, residues of antibiotics have been reported to accumulate in the tissues of fish, which in turn can enter the human food chain, creating potential health risks for humans (Ng'onga *et al*., 2025). In order to mitigate the aforementioned challenges, various researchers have emphasized the development of alternative approaches to prevent diseases and promote the health of fish in aquaculture systems. The most promising approach in this context has been the utilization of probiotics and prebiotics, which can be added to the diet of fish to promote their health and immune response (Akhter *et al*., 2015).

Probiotics in Aquaculture

Definition of Probiotics

Probiotics can be defined as live microorganisms that, when given in adequate amounts, have the ability to confer health benefits to the host. These beneficial microorganisms have been shown to enhance the balance of microbes in the gastrointestinal tract of the host, thus improving the health of the host as well as the host's growth performance in aquaculture (Mugwanya *et al*., 2022).

Common Probiotic Microorganisms

Various microorganisms have been identified as having the ability to act as probiotics in aquaculture. These microorganisms include bacteria such as Bacillus, Lactobacillus, Enterococcus, Pseudomonas, as well as yeast species such as Saccharomyces cerevisiae. These microbes have the ability to colonize the gastrointestinal tract of the host as well as confer health benefits to the host.

Sources of Probiotics

Probiotic microbes can be derived from a variety of sources, including the fish gut, aquatic environments, fermented foods, as well as commercially available microbes. These microbes are then introduced into the aquaculture system through the application of the microbes in the water or food of the fish, where the microbes colonize the

gastrointestinal tract of the host as well as interact with the host.

Mechanisms of Action of Probiotics

The mechanism of action of probiotics is based on several biological mechanisms. However, one of the most important mechanisms is competitive exclusion. In this mechanism, good bacteria compete with harmful microorganisms for food and attachment sites in the gastrointestinal tract. Such competition prevents harmful pathogens from colonizing and reproducing in fish (Akhter *et al*., 2015). The second mechanism is related to the production of antimicrobial substances that include bacteriocins, organic acids, hydrogen peroxide, and digestive enzymes. Probiotics produce antimicrobial substances that inhibit the multiplication of harmful pathogens in fish. Such antimicrobial substances maintain a healthy microbial environment in fish.

The third mechanism is related to the production of digestive enzymes that include proteases, amylases, and lipases. Probiotics produce digestive enzymes that facilitate the breakdown of proteins, carbohydrates, and lipids in fish feed. Such a process improves digestion in fish.Besides enhancing digestion in fish, probiotics stimulate their immune system. Probiotics increase phagocytic activity in fish and induce the production of immune molecules in fish. Probiotics also activate immune cells in fish that enhance their ability to fight diseases (Ng'onga *et al*., 2025).

Prebiotics in Aquaculture

Definition of Prebiotics

Prebiotics are non-digestible food ingredients that have a selective stimulation of the growth and activity of beneficial microorganisms in the gastrointestinal tract. Unlike prebiotics, which are live organisms, prebiotics are not alive but act as a food source for beneficial microorganisms in the gut (Ganguly *et al*., 2013).

Types of Prebiotics Used in Aquaculture

Several types of prebiotics are used in aquaculture. They include:

- Mannan Oligosaccharides (MOS)
- Fructo Oligosaccharides (FOS)
- Galacto Oligosaccharides (GOS)
- Inulin
- β-glucans

These compounds are added to fish diets to enhance fish health.

Mechanisms of Action of Prebiotics

The mechanism of action of prebiotics is mainly through their ability to act as a food source for beneficial microorganisms in the gut. When prebiotics are added to fish diets, when they reach the gut, they are fermented by beneficial microorganisms in the gut, thereby enhancing fish health (Ganguly *et al*., 2013). The mechanism of action of prebiotics is also through their ability to enhance gut structure and function in fish. Prebiotics act in a way that enhances the growth of beneficial microorganisms in the gut while suppressing pathogenic microorganisms.

The Role of Gut Microbiota in Fish Health

The gastrointestinal tract of fish harbors a complex and diverse population of microorganisms, and this population of microorganisms in the gut of fish is referred to as gut microbiota. The gut microbiota plays a crucial role in the digestion of food, metabolism, immune response, and prevention of diseases in fish (De Marco *et al*., 2023). The gut microbiota of fish has a symbiotic effect on the host fish and plays a crucial role in the breakdown of complex substances in the diet

of fish. The microbial fermentation of these substances in the gut of fish results in the production of beneficial substances like vitamins, enzymes, and short-chain fatty acids, which have a positive effect on the metabolic activities of the host fish.

However, the gut microbiota of fish can be affected by various factors like diet, environment, fish species, and aquaculture practices. The disruption of gut microbiota in fish caused by stress, poor water quality, and diseases has a negative effect on the health of fish. Probiotics and prebiotics administration helps in restoring the microbial balance in the body and maintaining intestinal health. The additives help in modulating the microbial community and improving the body's defense mechanisms against harmful pathogens (Di Marco *et al*., 2023).

Benefits of Probiotics and Prebiotics in Aquaculture

Improved Growth Performance

The use of probiotics and prebiotics improves the digestive and nutritional status of fish, thus enhancing their growth performance.

Enhanced Immune Response

The probiotics and prebiotics induce an immune response in fish, which protects them from diseases. The immune response includes the activation of phagocytic cells, lysozyme, and complement, which enhance the resistance of fish to diseases (Akhter *et al*., 2015).

Increased Disease Resistance

The probiotics and prebiotics prevent the establishment of disease-causing organisms in fish and induce an immune response in the fish, thus enhancing their resistance to diseases.

Improved Water Quality

The probiotics have the potential to break down organic matter in the culture environment, thus improving the water quality in the culture environment. The probiotics have the potential to break down ammonia and nitrite in the culture environment.

Reduced Antibiotic Dependency

The probiotics and prebiotics have the potential to reduce the dependency on antibiotics in the culture environment, thus enhancing the sustainability of the culture environment (Ng'onga *et al*., 2025).

Challenges and Future Perspectives

Despite the advantages of the application of probiotics and prebiotics in aquaculture, it has been found that the efficacy of such applications may vary according to the strain of microbes, species of the host, and the environment. Hence, it is necessary to select the appropriate strain of microbes and prebiotics to attain the best results.In the future, the development of species-specific probiotics and the development of better delivery systems of microbes in feed additives should be the focus of research in the field of aquaculture.

It is also anticipated that advances in the field of microbiome studies will lead to better understanding of the interaction of microbes in aquaculture systems. The application of synbiotics, i.e., the combination of both prebiotics and probiotics, has also been found to be a promising tool in the field of aquaculture to enhance the health of fish as well as the productivity of aquaculture systems (Mugwanya *et al*., 2022).

CONCLUSION

Probiotics and prebiotics are promising and sustainable alternatives to antibiotics used in

aquaculture health management. These functional feed additives can promote a balanced gastrointestinal microbiota, enhance digestion, and stimulate immunity and disease resistance in aquatic animals. The use of these functional feed additives has a great potential to promote growth rates, survival rates, and environmentally sustainable aquaculture production. Further research and appropriate strategies on their applications will definitely enhance the role of probiotics and prebiotics in promoting fish health and aquaculture sustainability.

REFERENCE

Akhter, N., Wu, B., Memon, A. M., & Mohsin, M. (2015). Probiotics and prebiotics associated with aquaculture: a review. *Fish & shellfish immunology*, *45*(2), 733-741.

Dawood, M. A., & Koshio, S. (2016). Recent advances in the role of probiotics and prebiotics in carp aquaculture: a review. *Aquaculture*, *454*, 243-251.

Di Marco, A., Soffitta, P., Costa, E., Ferrazzoli, R., La Monaca, F., Rankin, J., ... & Weisskopf, M. C. (2023). Handling the background in IXPE polarimetric data. *The Astronomical Journal*, *165*(4), 143.

Ganguly, S. (2013). Supplementation of prebiotics, probiotics and acids on immunity inpoultry feed: a brief review. *World's poultry science journal*, *69*(3), 639-648.

Mugwanya, M., Dawood, M. A., Kimera, F., & Sewilam, H. (2022). Updating the role of probiotics, prebiotics, and synbiotics for tilapia aquaculture as leading candidates for food sustainability: a review. *Probiotics and antimicrobial proteins*, *14*(1), 130-157.

Ng'onga, L., Amoah, K., Chen, H., Huang, Y., Wang, B., Shija, V. M., ... & Adjei-Boateng, D. (2025). The metabolism and antioxidant properties of probiotics and prebiotics in fish: a review. *Frontiers in Marine Science*, *12*, 1622474.