AgriCos e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 06 Issue: 04 April 2025 Article No: 08

Probiotic Applications for Gut Microbiota Optimization and Disease Prevention in Aquaculture

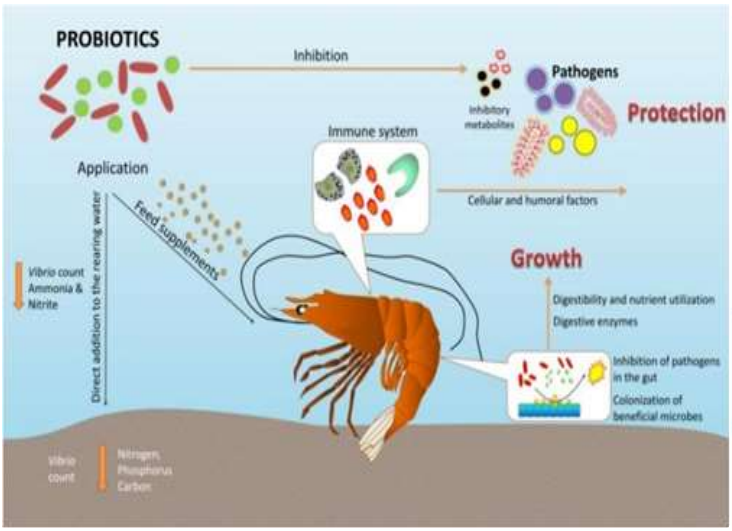
R. Arasi, V. Rani and D. Manimekalai
Department of Aquatic Environment Management, Fisheries college and Research Institute, Thoothukudi, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Tamil Nadu

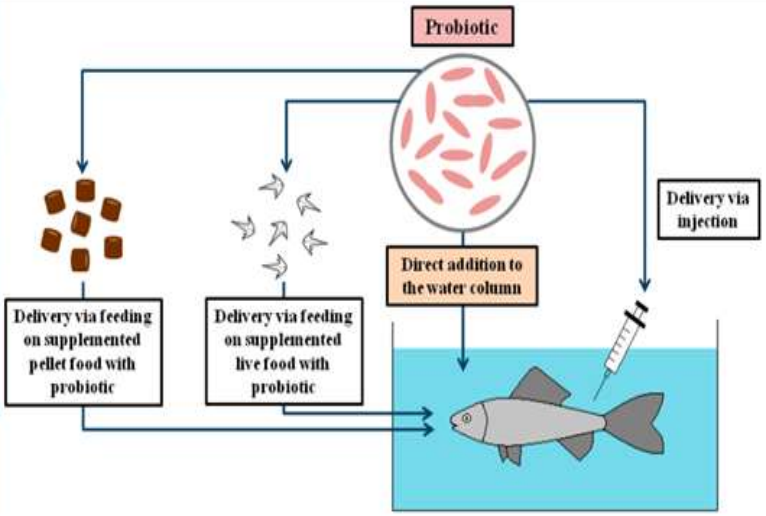
SUMMARY

Probiotics play a vital role in enhancing gut microbiota balance and disease resistance in fish and shrimp. These beneficial microorganisms contribute to improved nutrient absorption, immune modulation, and inhibition of pathogenic bacteria, reducing the reliance on antibiotics in aquaculture. Additionally, probiotics enhance stress tolerance, support detoxification, and mitigate inflammation, promoting overall resilience in aquatic species. The use of probiotics as a sustainable alternative to antibiotics minimizes the risk of antimicrobial resistance and promotes environmentally friendly aquaculture practices. The benefits of such supplements include improved feed value, enzymatic contribution to digestion, inhibition of pathogenic microorganisms, anti-mutagenic and anti-carcinogenic activity, and increased immune response. These probiotics are harmless bacteria that help the well-being of the host animal and contribute, directly or indirectly to protect the host animal against harmful bacterial pathogens.

INTRODUCTION

Aquaculture is a rapidly growing industry that plays a vital role in ensuring global food security. However, it faces numerous challenges, including frequent disease outbreaks, environmental stress, and excessive antibiotic use, which can contribute to antimicrobial resistance and ecological disruption. The use of probiotics as a natural and sustainable alternative has shown great potential in improving gut microbiota balance, enhancing nutrient absorption, and boosting immune function in fish and shrimp. These beneficial microorganisms support intestinal health, inhibit harmful pathogens, and optimize digestive processes, ultimately improving overall health and survival rates. By promoting a stable gut microbiome, probiotics enhance growth efficiency, improve feed utilization, and strengthen disease resistance and stress tolerance. Their incorporation into aquaculture systems reduces dependency on antibiotics and chemical treatments, fostering a more sustainable and resilient aquaculture industry. During the last decades, antibiotics used as traditional strategy for fish diseases management and also for the improvement of growth and efficiency of feed conversion. An alternative approach to manage fish and shrimp health, that is fast gaining attention in aquaculture industry is, “probiotics”, a microbial intervention approach for disease prevention and control, high survival and growth by enhancing the feed conversion efficiency. Probiotics introduced for aquaculture have several forms including bacterial cells. Commonly used probiotic micro-organisms are *Bacillus* sps: *Lactobacilus* sp, *Enterococcus* sp, *Carnobacterium* sp, and the yeast, Saccharomyces cerevisiae, etc. Application of antimicrobial agents in aquaculture practices can be reduced by encouraging the usage of immunestimulants, non-specific immune enhancers, probiotics and vaccines.





Probiotics

Probiotics is a Greek words “pro” and “bios” meaning “for life”; generally referred to microbial feed additives which confer host organism through modulation of intestinal microbiota. Parker (1974) was the first who defined probiotics as organisms and substances that affect microbial in intestine. According to the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), probiotics are live microorganisms which are used orally having some tangible health benefits to the host. Probiotic is a bacteria-based product in which essential bacteria is used to promote health, prevent multiple diseases and pathogenic growth in aquaculture. The use of non-pathogenic bacteria can also improve dietary safety and environmental performance, which can control allergies and improve the immune system by altering host-related microorganisms.

Role of probiotics in Gut Microbiota Modulation

Gut Microbiota and Its Importance

Gut microbiota refers to the diverse community of microorganisms, including bacteria, fungi, and protozoa, residing in the gastrointestinal tract of fish and shrimp. These microbes play a crucial role in digestion, immunity, disease resistance, and overall health. A balanced gut microbiota is essential for optimal growth and survival in aquaculture species. The composition of gut microbiota in fish and shrimp is highly diverse and influenced by factors such as species, diet, environment, and health status. It consists of three main groups such as beneficial bacteria, opportunistic bacteria, and pathogenic bacteria.

Beneficial bacteria, including *Lactobacillus*, *Bacillus*, *Pseudomonas*, and *Enterococcus*, play a key role in digestion, nutrient absorption, and immune system stimulation. These microbes produce digestive enzymes, vitamins, and antimicrobial compounds that enhance gut health and overall well-being.

Opportunistic bacteria, such as *Aeromonas*, *Vibrio*, and *Pseudomonas*, are naturally present in the gut but can become harmful under stress conditions like poor water quality or nutritional imbalances.

Pathogenic bacteria, including *Vibrio harveyi*, *Edwardsiella tarda*, and *Aeromonas hydrophila*, can cause severe infections, leading to high mortality in aquaculture. Additionally, gut microbiota may include fungi, archaea, and protozoa, which contribute to microbial interactions and nutrient cycling. The dynamic nature of gut microbiota makes it essential to maintain a balanced microbial community through proper diet, probiotics, and environmental management to support the health and productivity of farmed fish and shrimp.

Functions of Gut Microbiota

The gut microbiota in fish and shrimp plays a crucial role in various physiological functions, including digestion, immunity, and disease resistance. One of its primary functions is digestion and nutrient absorption, where beneficial bacteria produce digestive enzymes that break down complex carbohydrates, proteins, and lipids, enhancing feed utilization and growth. Some microbes also synthesize essential vitamins like B-complex vitamins and vitamin K, contributing to metabolic processes. Another vital function is immune system modulation, where gut bacteria stimulate immune responses by enhancing mucosal immunity, producing antimicrobial peptides, and regulating inflammatory pathways, thereby improving resistance against infections. Additionally, gut microbiota play a key role in pathogen exclusion, preventing harmful bacteria such as *Vibrio* and *Aeromonas* from colonizing the gut by competing for nutrients and attachment sites. The microbiota also contribute to metabolic regulation, influencing lipid metabolism, energy production, and overall growth performance. Furthermore, a well-balanced gut microbiota helps improve stress tolerance and environmental adaptation, enabling fish and shrimp to cope with changes in water quality, salinity, and temperature fluctuations. Maintaining a stable gut microbiome through probiotics, prebiotics, and optimal aquaculture management is essential for enhancing health, immunity, and productivity in aquatic species.

Mechanism of action of probiotics

Probiotic selection depends on their colonization, antagonism to pathogens and therefore the production of beneficial compounds like vitamins, fatty acids and digestive enzymes. For the successful application of probiotic strains as microbial ingredients in fish, other characteristics seem to be essential, like high viability during processing, storage and after gastro-intestinal transit. Major Probiotic mechanisms of action include enhancement of the epithelial barrier, increased adhesion to the intestinal mucosa, and competitive exclusion of pathogenic microorganisms and production of anti-microorganism substances

- Enhancement of the epithelial barrier: The intestinal barrier is a major defense mechanism used to maintain epithelial integrity and to protect the organism from the environment.

- Increased adhesion to intestinal mucosa: Adhesion to intestinal mucosa is regarded as a prerequisite for colonization and is important for the interaction between probiotic strains and the host.
- Competitive exclusion of pathogenic microorganisms: Probiotics bacteria bind with the binding sites in the intestinal mucosa, forming a physical barrier, preventing the connection by pathogenic bacteria;
- Production of anti-microorganism substances: Organic acids, in particular acetic acid and lactic acid, have a strong inhibitory effect against Gram-negative bacteria, and they have been considered the main antimicrobial compounds responsible for the inhibitory activity of probiotics against pathogenic microbes

CONCLUSION

Probiotics play a crucial role in maintaining gut microbiota balance, improving digestion, and enhancing disease resistance in fish and shrimp. By promoting beneficial bacteria, inhibiting pathogens, and strengthening immune function, probiotics contribute to better growth, higher survival rates, and improved stress tolerance. Their use as a natural alternative to antibiotics reduces the risks associated with antimicrobial resistance and promotes sustainable aquaculture practices. However, the effectiveness of probiotics depends on factors such as strain selection, dosage, and administration methods. Future research should focus on optimizing probiotic formulations and exploring synbiotic approaches to maximize their benefits. Integrating probiotics into aquaculture management will be essential for improving aquatic species' health, ensuring sustainable production, and supporting global food security.

REFERENCES

Ghosh S, Sinha A, Sahu C. Effect of probiotic on reproductive performance in female live bearing ornamental fish. Aquaculture Research. 2007 Mar;38(5):518-26

Newaj-Fyzul, A., AH Al-Harbi and Austin B. "Developments in the use of probiotics for disease control in aquaculture." Aquaculture 431 (2014): 1-11

Rowland I., Gibson G., Heinken A., Scott K., Swann J., Thiele I., Tuohy K. Gut microbiota functions: Metabolism of nutrient and other food components. Eur. J. Nutr. 2018;57:1–24. doi: 10.1007/s00394-017-1445-8

Wang A.R., Ran C., Ringø E., Zhou Z.G. Progress in fish gastrointestinal microbiota research. Rev. Aquac. 2018; 10:626–640. doi: 10.1111/raq.12191.