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Unwinding the Potential of Probiotics in Aquaculture

Sujani Gudipati
Head R and D, Advance Aqua Bio Technologies India Private Limited AABT Global Towers, D.No. 7-776, Tadigadapa-Enikepadu 100 feet Road, Kanuru, Vijayawada-521137, Krishna (Dist), A.P., INDIA
Corresponding email: research@aabt.in

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Abstract: The recent past has seen an over growing interest in the probiotics, considering them as efficient bioremidiators, due to their therapeutic and prophylactic activities. More so in aquaculture where the need for growth, feed efficiency, water quality, disease resistance and immunity are of prominence. Earlier studies and research on the role of the probiotics in aquaculture prove their importance and efficiency. The planned combination of formulated probiotics improved the health and nutrition of the organism, also enhanced the water quality by proper breakdown of the organic matter, reducing the toxic nitrogenous compounds to the non-toxic forms, reduction of the bacterial and microbial loads. Probiotics seem to install, improve and compensate for the various functions of the pond ecosystem and the organism therein. This study tried to explore, in an authenticated manner, the probiotic potential in aquaculture, focusing mainly on the mechanism, methods of applications, mode of action, focusing on their advantages over existing practices. The findings of this study highlight the importance of addition of probiotics to aquaculture, these work by preventing the colonization of the harmful bacteria, reduce the microbial load by competitive exclusion, promote sustainability and environmental health by their enzymatic mechanism. A kind of bioremidiation, using the beneficial living strains with no risk of toxicity and developing resistance, unharmful to the aquaculture system and the environment.

Keywords: Bio remediation; Colonization; Competitive exclusion; Enzymatic mechanism; Living strains; Microbial; Probiotics

1 Introduction

1.1 Overview of probiotics in aquaculture

Interest in biologically active products with potential beneficial effects, both theraupetic and prophylactic purposes has increased significantly (Soccol et al., 2010). Currently several such products containing one or a combination of many strains have flooded the market, choosing amongst these has stood a challenge. In recent years due to the limitation of the use of chemicals and synthetic substances, use of these microorganisms called Probiotics, for good production and prevention of diseases and their implications has come to the fore front (Irianto and Austin, 2002).

1.2 Importance of probiotics as alternatives to chemicals and antibiotics

Probiotics as the name suggests, these are live microbial feed supplements that have beneficial effects on the host by improving its intestinal microbial community balance of the feed (Verschuere et al., 2000). Associated with the host or environment, ensuring better utilization or and also improving the nutritional value. Improving the host's response against a disease and also improving the quality of its environment. Living strains of bacteria that add to the population of good bacteria (Figure 1) (Ghosh et al., 2008).

In Latin PRO-means before forward and bios-life, thus Probiotics are life promoting, in this case the beneficial bacteria that belong to nearly 20 bacterial genera falling under-Bacilli, *Lactobacilli* and *Bifido*. Probiotics like *Lactobacillus plantarum* enhances growth and immunity (Dohail et al., 2009), *Bacillus subtilus* helps in converting Ammonia and Carbon dioxide to available Carbon and nutrient (Shishehchian et al., 2001; Lalloo et al., 2007).

2 Mechanisms of Probiotic Action

2.1 How probiotics work in aquaculture

Probiotics produce low molecular weight antibacterial substance (Vijayan et al., 2006; Jinendiran et al., 2021). They use enzymatic mechanism to modify toxin receptors and block toxin mediated pathology. They prevent colonization of pathogenic micro-organism by Competitive inhibition for microbial adhesion sites (Figure 3). They produce Lactic acid and lowers pH that inhibits bacterial growth (Figure 2) (Balcazar et al., 2006).

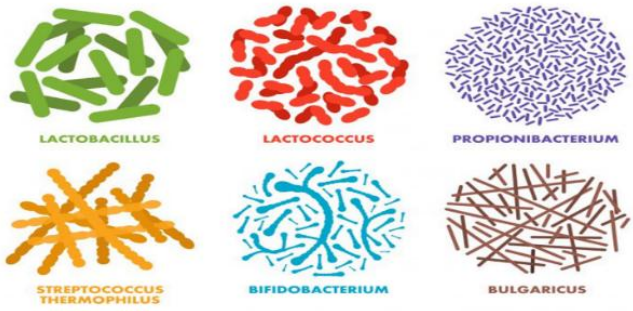

Figure 1 Types of probiotic strains used in aquaculture and their functions

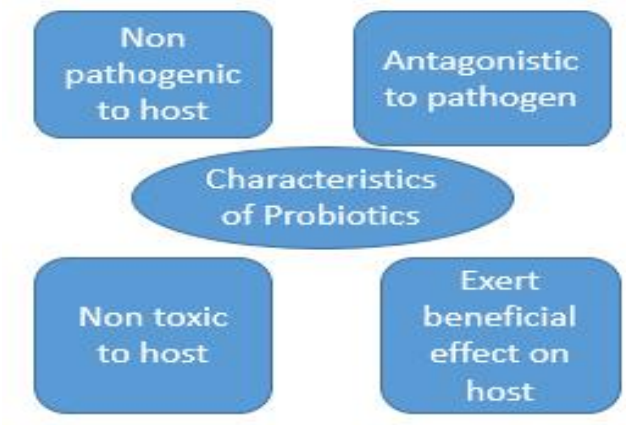

Figure 2 Key characteristics of probiotics and their impact on aquaculture

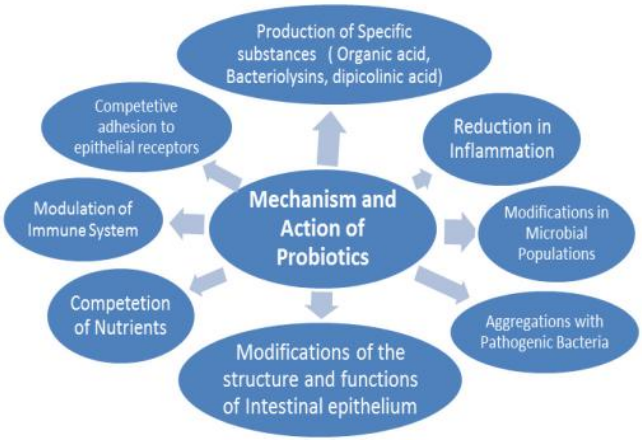

Figure 3 Mechanisms by which probiotics enhance immunity and improve water quality

2.2 Specific actions of different probiotic strains

Each individual strain has its unique way of functioning and action on the pathogen. *Bacillus subtilis* shows high stability, immune modulation and enhanced digestibility, takes care of gut health and growth performance, enhances disease resistance. *Bacillus licheniformis* enhances nutrient digestion and utilization by producing

enzymes like lipase, protease and amylase. Unique capability to synthesize a range of antibacterial compounds. Bacillus coagulans-protects intestinal lining acts as a barrier, relieves from infections (Lara et al., 2003).

Lactobacillus Colonize in the gut, prevent and protect pathogen infections, improve digestion, help weight gain and resistance. Improve water quality too. *Rhodococcus* increase growth, pigmentation and survival rate. Capable of metabolizing harmful environmental inclusions. *Rhodobacter* improves growth, intestinal micro flora, inhibits *Aeromonas*, increases fish resistance and improves water quality. *Nitrosomonas-Oxidise* toxic ammonia to non-toxic nitrites through the nitrification process. Reduction of Ammonia in the pond. *Nitrobacter-Oxidize* Nitrite to Nitrate, very important inorganic nitrogen used by the primary producers. Reduction in Ammonia.

2.3 Mode of probiotic administration

Probiotics are basically of 2 types Gut and Water. The Gut Probiotics are administered through feed, Water Probiotic by direct application and via injection. 90% of the probiotic in aquaculture are given through feed, 8 % through water, the other methods are still naïve. Probiotics can be used alone or in combination (Figure 4) (Ringø et al., 2008).

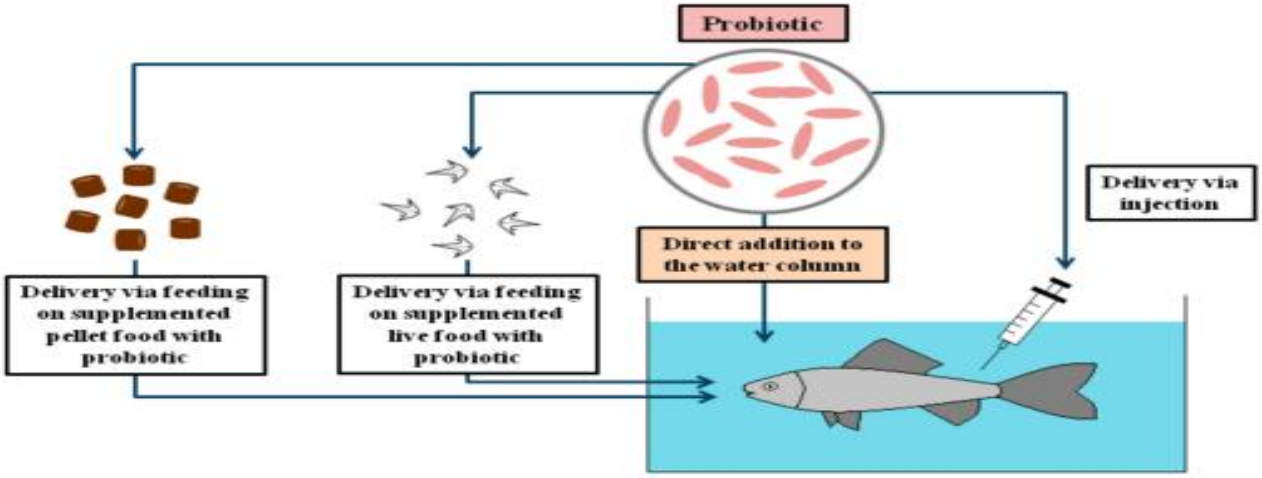

Figure 4 Modes of probiotic administration in aquaculture-gut and water

3 Benefits of Probiotics In Aquaculture

3.1 Effects on growth and immunity

The varied probiotics are, so varied is their working on individual species of aquatic organisms playing a vital role in their growth, health and immunity, by their positive impact on the biology and physiology of the organisms (Figure 5, Figure 6, Figure 7) (Medina et al., 2023).

In Aquaculture, probiotics are used as live, dead or as a component of formulations. Administered through feed or water. Probiotics in aquaculture are used as alternative to antibiotics and synthetic or non-synthetic chemical substances, the use which in past over years seems to have caused more irreversible harm than good to aquaculture. While Probiotics have entered taking care of the situation (Schrezenmeir et al., 2001).

4 Comparative Analysis

4.1 Comparison with antibiotics and chemicals

4.1.1 Probiotics effectiveness over traditional methods

Traditionally anti biotics and chemicals have been used, using these though gave results initially, but developed resistance and side effects that proved fatal sometimes, but now Probiotics are treated as the natural substitutes for antibiotics and other substances. Since the Probiotics improve the body's immunity by colonizing in the gut and preventing the colonization of the deleterious bacteria, By competitive exclusion removes the pathogens (Spanggaard et al., 2001), maintain the epithelial barrier and restore the gut balance.

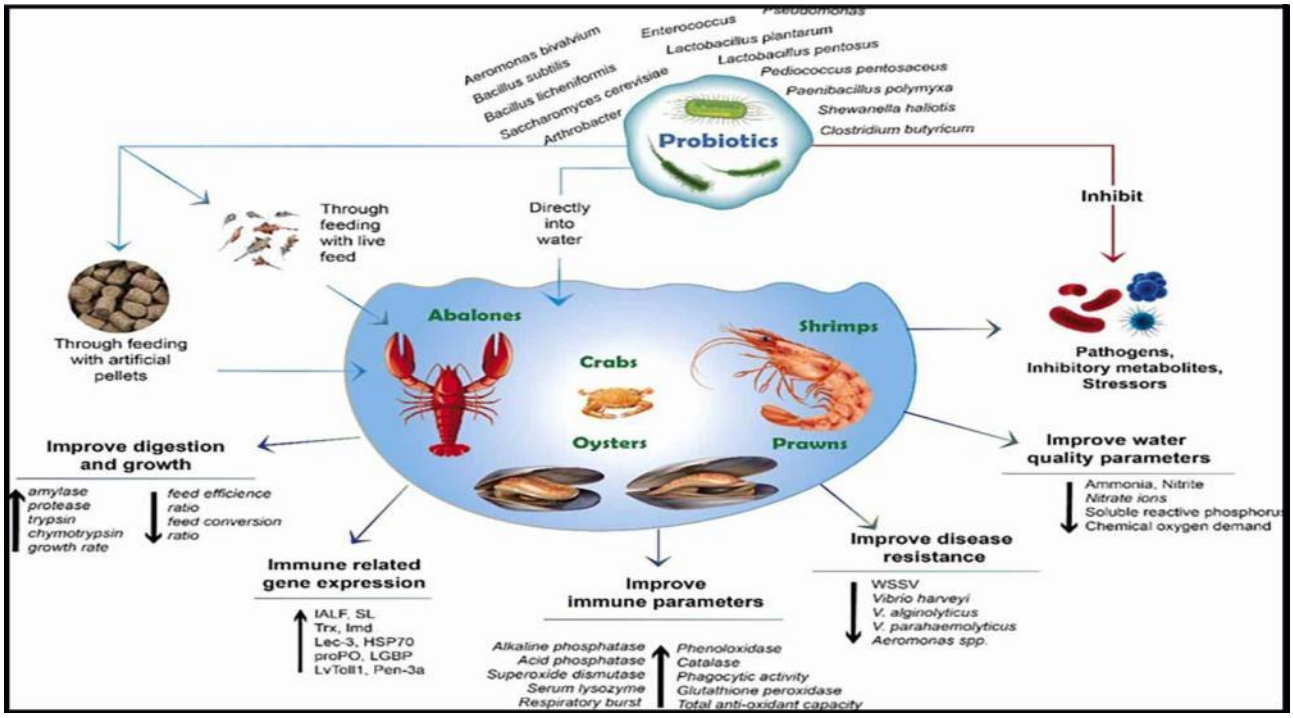

Figure 5 Benefits of Probiotics on Growth and Immunity in Aquaculture

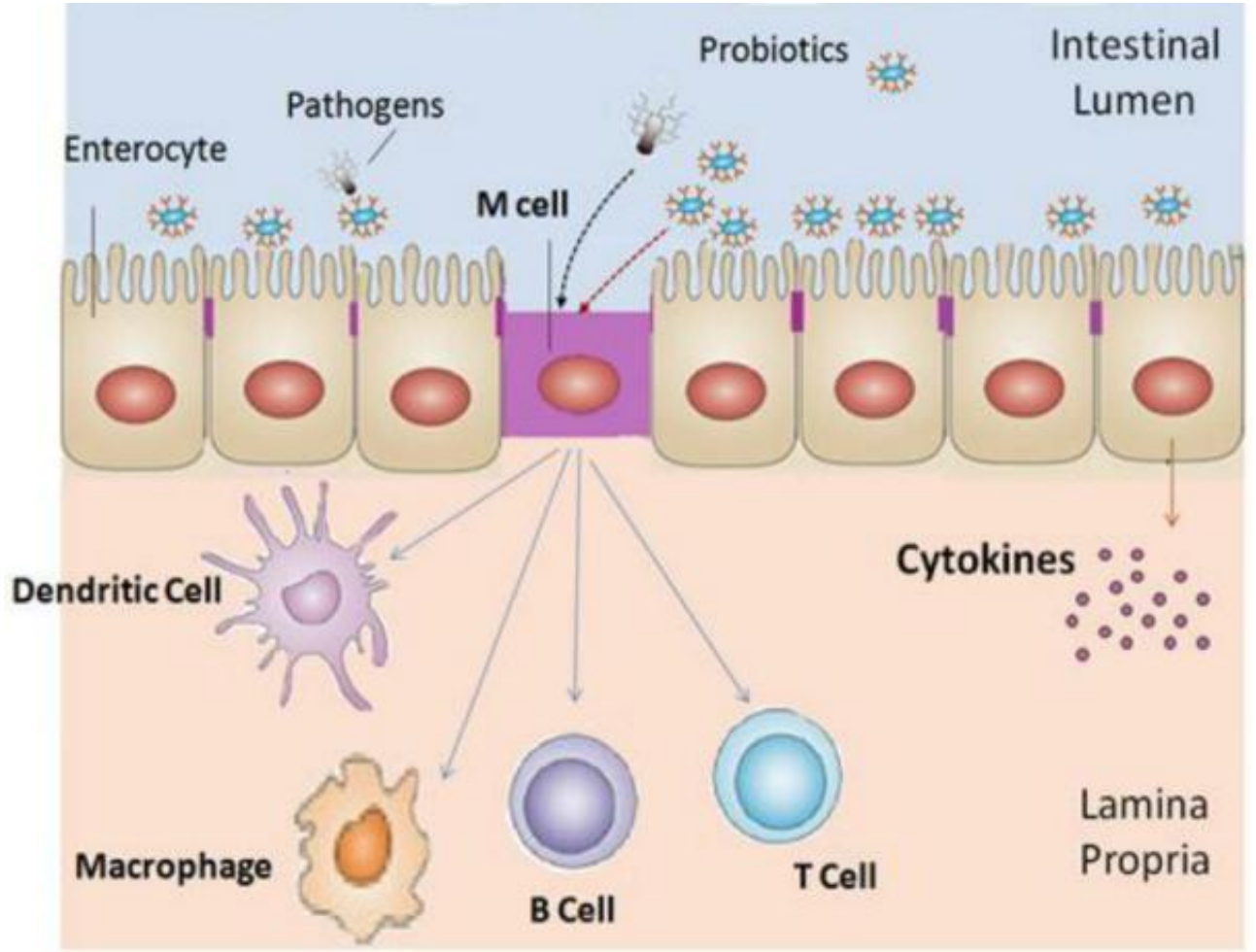

Figure 6 Physiological actions of probiotics in aquaculture

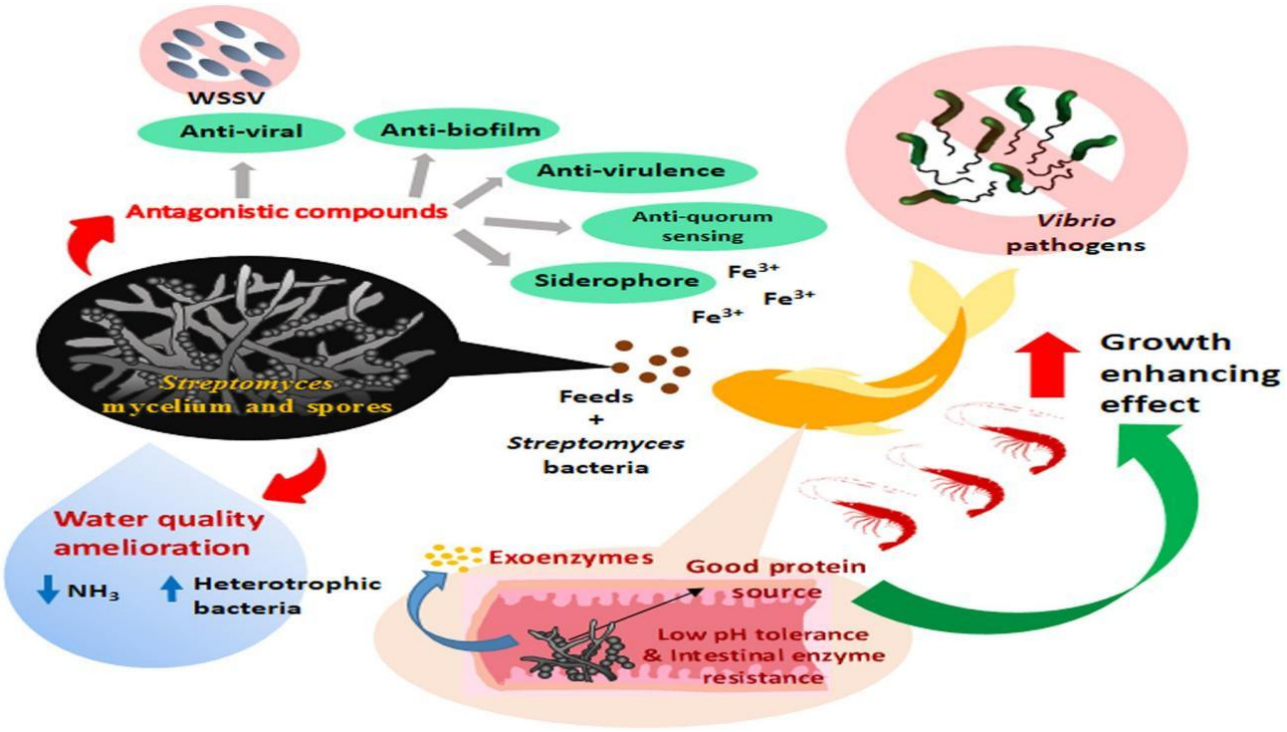

Figure 7 Probiotic activity in gut and its impact on health

4.2 Comparison with Antibiotics

Antibiotics do work against harmful bacteria but also eradicate the beneficial bacteria too, their use leads to other issues like inflammation, Mycosis, inflammation and mainly resistance to antibiotics. Prebiotics are said to increase the level of drug resistant gene expression, prevent antibiotic related issues like diarrhea, inflammation etc. and mainly no harm to the beneficial bacteria, without the development of any resistance, stimulate the immune system and better the ability to defend the pathogens.

4.3 Advantages and Limitations

4.3.1 Advantages of probiotics

Growth and rebalance of macrobiota. Enhance energy and renewal of the epithelial cells. Act as strong intestinal barrier, enhance the immune system. Constrain the adhesion and growth of pathogens.

4.3.2 Limitations of probiotics

The only concern for the commercial formulations is maintaining the quality and the ability to survive storage conditions, remaining stable and viable (Wang et al., 2008).

4.3.3 Environmental impact

Probiotics have a positive environmental impact on the environment, they improve fish health and growth, reduce disease and the production costs. They reduce pollutants and it is said they reduce the Carbon dioxide emissions of the water by nearly 30%.

4.4 Significance of probiotics in fish culture

Probiotics play a critical role in enhancing fish culture by addressing multiple facets of aquaculture health and productivity. Their application significantly promotes fish growth and metabolism by optimizing nutrient assimilation and feed efficiency. By bolstering the immune response, probiotics provide enhanced resistance against diseases and improve the overall vitality and performance of aquatic organisms. In terms of environmental management, probiotics contribute to maintaining superior water quality by balancing dissolved oxygen levels and facilitating the effective utilization of carbon dioxide and nitrites. Nitrifying probiotic bacteria, such as Nitrosomonas and Nitrobacter, are particularly crucial as they convert toxic ammonia into non-toxic nitrites and

nitrates, thereby mitigating ammonia and nitrate toxicity. This transformation not only supports the health of aquatic organisms but also boosts the pond's primary productivity. Probiotics also help preserve the delicate balance of intestinal microflora, preventing dysbiosis and ensuring a robust digestive environment. Their enzymatic mechanisms enhance the breakdown of organic matter, reducing microbial loads and harmful nitrogenous compounds. This bioremediation capacity fosters a sustainable aquaculture ecosystem, reducing reliance on harmful chemicals and antibiotics. Furthermore, probiotics improve the resilience of fish to stress, enhance vigor, and support a favorable environment for growth and reproduction (Figure 8) (Castex et al., 2009). By integrating probiotics into fish culture, aquaculture systems achieve better feed conversion rates, reduced input costs, and a healthier, more sustainable aquatic environment.

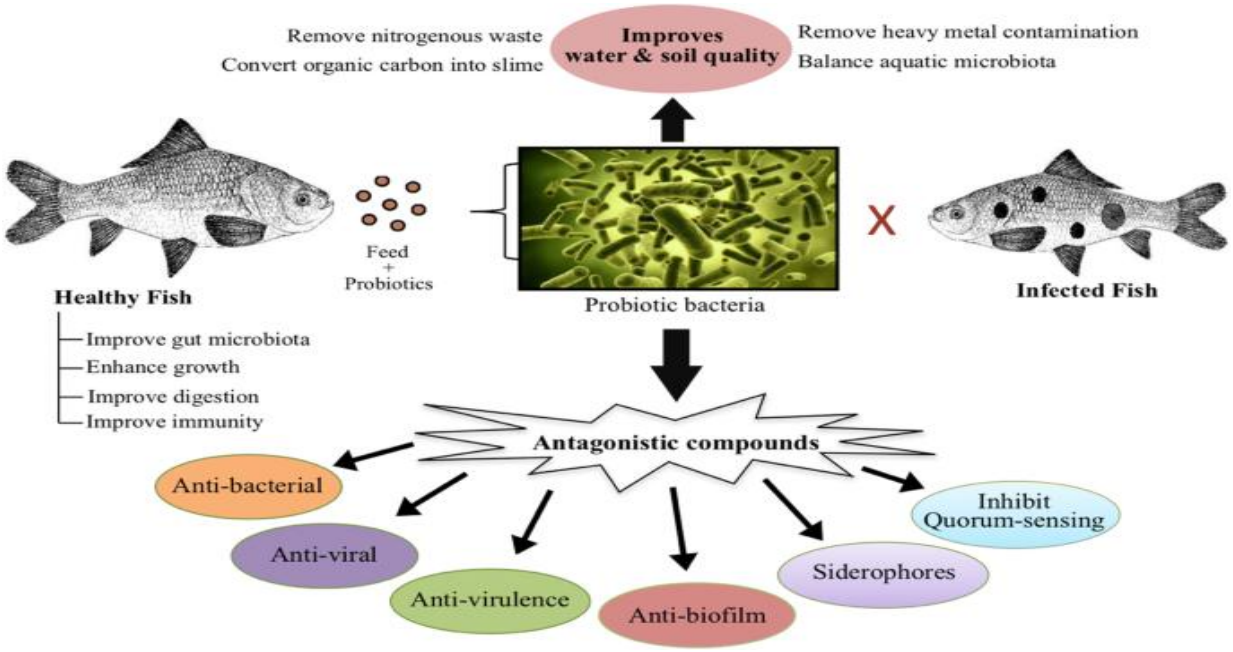

Figure 8 Comparison of probiotic-treated vs untreated fish

4.5 Significance of probiotic in shrimp culture

Competitive exclusion of pathogenic bacteria and other microorganisms. Enhancement of digestion through production of digestive exoenzymes (Wang et al., 2004). Moderating and promotion of direct uptake of dissolved organic materials. Inhibiting the growth of pathogenic bacteria through production of antibodies. Controlling the reproduction and proliferation phyto plankton and blue green algal blooms. Preventing off flavours of meat and in the water too (Figure 9) (Zorriehzahra et al., 2016).

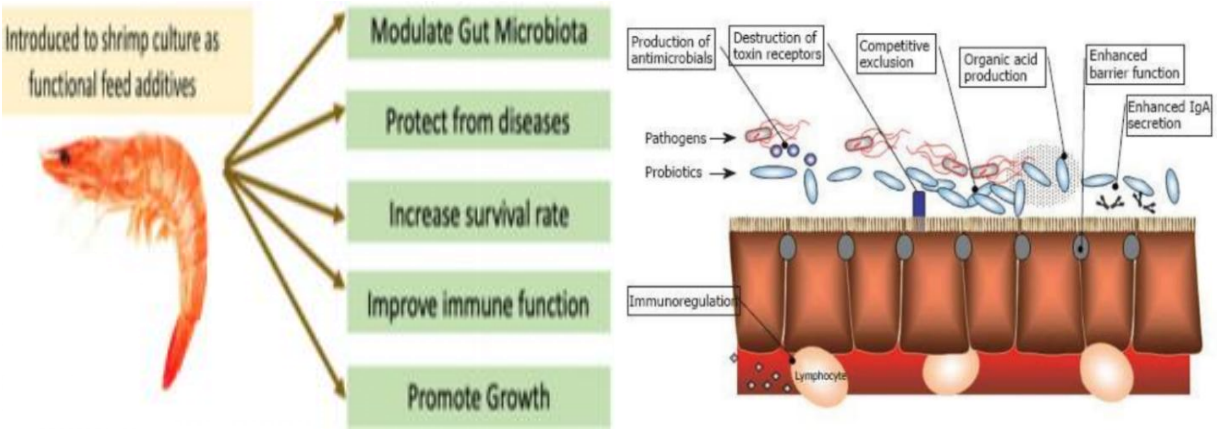

Figure 9 Mechanisms and benefits of probiotics in shrimp farming

5 Conclusion

A Global trend seems to have been created in the use of Probiotics in aquaculture. Probiotics act as an aquacultural tool and as a healthy alternative to the control of new pathogens, emerging diseases (Wang et al., 2008), that are of commercial interest too. These are the best economical substitutes to the bad bacteria that harbor the pond. Probiotics function by acting as nutrient sources. Probiotics provide enzymes for better digestion. Probiotics modulate the immune system to resist infections (Figure 10). Probiotics enhance immune response to fasten up recovery (Wang et al., 2008; Merrifield et al., 2010).

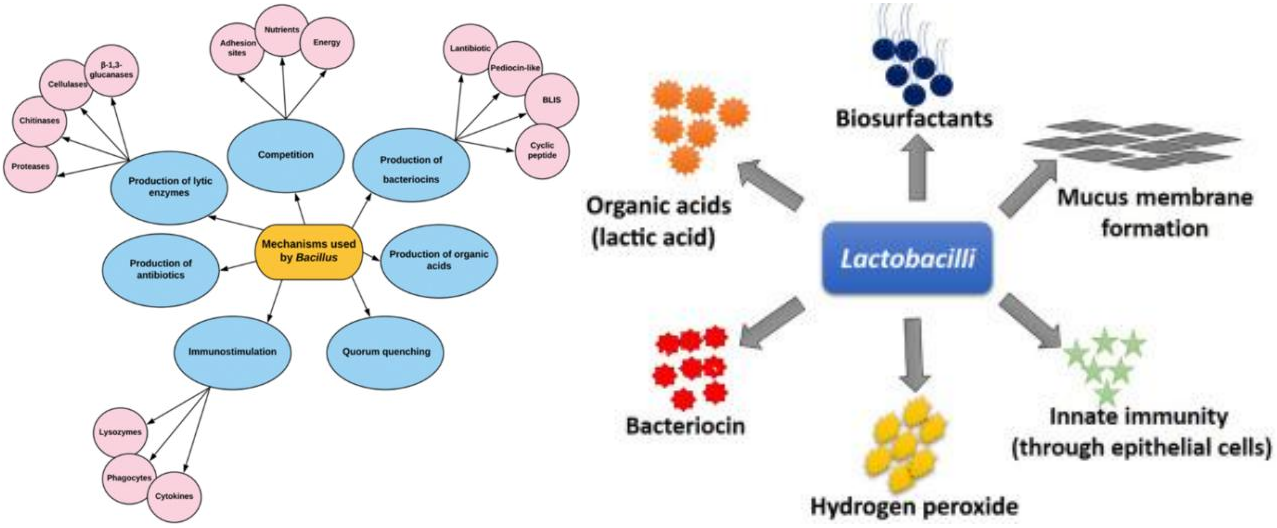

Figure 10 Probiotic-mode of action

Advance Aqua Bio Technologies India Pvt. Ltd, has pioneered in its Probiotic presentations like AQUA PS, BIO STIM, BIO PROB etc. and is proud of their market presence. These are completely planned Probiotic formulations with every grain of them carrying the same competence (Wang et al., 2008). Efficient in both aerobic and anaerobic conditions. Control and prevent harmful bacterial growth in water and in the gut, with a capacity to neutralize the toxic and unwanted gases, reduce ammonia, BOD and COD levels, digest the unused organic matter like proteins, lipids and carbohydrates and metabolize them into useful forms. Provide favourable environment to the aquatic organism. Enhance the host defense, immunity and disease resistance. All this resulting in better feed conversion efficiency, healthier inmates with faster growth and greater production, with a reduction in input costing by about 20%. That being surely substantial.

Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

Reference

Al-Dohail M.A., Hashim R., and Aliyu-Paiko M., 2009, Effects of the probiotic, *Lactobacillus acidophilus*, on the growth performance, haematology parameters and immunoglobulin concentration in African catfish (*Clarias gariepinus*, Burchell 1822) fingerling, Aquaculture Research, 40(14): 1642-1652.
https://doi.org/10.1111/j.1365-2109.2009.02265.x

Balcázar J.L., de Blas I., Ruiz-Zarzuela I., Cunningham D., Vendrell D., and Múzquiz J.L., 2006, The role of probiotics in aquaculture, Veterinary Microbiology, 114(3-4): 173-186.
https://doi.org/10.1016/j.vetmic.2006.01.009

Castex M.. Lemaire P. Wabete N., and Chim L., 2009, Effect of dietary probiotic *Pediococcus acidilactici* on antioxidant defences and oxidative stress status of shrimp *Litopenaeus stylirostris*, Aquaculture, 294(3-4): 306-313.
https://doi.org/10.1016/j.aquaculture.2009.06.016

Ghosh A. Sinha A.and Sahu C., 2008, Dietary probiotic supplementation on growth and health of live-bearing ornamental fishes, Aquaculture Nutrition, 14(4): 289-299.
https://doi.org/10.1111/j.1365-2095.2007.00529.x

Irianto A., and Austin B., 2002, Probiotics in aquaculture, Journal of Fish Diseases, 25(11): 633-642.
https://doi.org/10.1046/j.1365-2761.2002.00422.x

Jinendiran S., Archana R., Sathishkumar R., Kannan R., Selvakumar G., and Sivakumar N., 2021, Dietary administration of probiotic *Aeromonas veronii* v03 on the modulation of innate immunity, expression of immune-related genes and disease resistance against aeromonas hydrophila infection in common carp (*Cyprinus carpio*), Probiotics and Antimicrobial Proteins, 13: 1709-1722.
https://doi.org/10.1007/s12602-021-09784-6

Lalloo R. Ramchuran S. Ramduth D. Görgens J., and Gardiner N., 2007, Isolation and selection of *Bacillus* spp. as potential biological agents for enhancement of water quality in culture of ornamental fish, Journal of Applied Microbiology, 103(5): 1471-1479.
https://doi.org/10.1111/j.1365-2672.2007.03360.x

Lara-Flores M., Olvera-Novoa M.A., Guzmán-Méndez B., and López-Madrid W., 2003, Use of the bacteria *Streptococcus faecium* and *Lactobacillus acidophilus*, and the yeast *Saccharomyces cerevisiae* as growth promoters in Nile tilapia (*Oreochromis niloticus*), Aquaculture, 216(1-4): 193-201.
https://doi.org/10.1016/S0044-8486(02)00277-6

Medina A., García-Márquez J., Moriñigo M.Á., and Arijo S., 2023, Effect of the Potential Probiotic Vibrio proteolyticus DCF12.2 on the immune system of solea senegalensis and protection against *Photobacterium damselae subsp*. piscicida and *Vibrio harveyi*, Fishes, 8(7): 344.
https://doi.org/10.3390/fishes8070344

Merrifield D.L., Dimitroglou A., Foey A., Davies S.J., Baker R.T., Bøgwald J., Castex M., Ringø E., 2010, The current status and future focus of probiotic and prebiotic applications for salmonids, Aquaculture, 302: 1-18.
https://doi.org/10.1016/j.aquaculture.2010.02.007

Ringø E., Van Doan H., Lee S.H., Soltani M., Hoseinifar S.H., Harikrishnan R., Song S.K., 2020, Probiotics, lactic acid bacteria and bacilli: Interesting supplementation for aquaculture, Journal Of Applied Microbiology, 129: 116-136.
https://doi.org/10.1111/jam.14628

Schrezenmeir J., and de Vrese M., Probiotics, 2001, Prebiotics, and synbiotics-approaching a definition, American Journal of Clinical Nutrition, 73: 361S-364S.
https://doi.org/10.1093/ajcn/73.2.361s

Shishehchian F., Yusoff F.M., and Shariff M., 2001, The effects of commercial bacterial products on macrobenthos community in shrimp culture ponds, Aquaculture International, 9(5): 429-436.
https://doi.org/10.1023/A:1020582417487

Soccol C.R., de Souza V.L.P., Spier M.R., Pedroni M.A.B., Yamaguishi C.T., Lindner J.D.D., Pandey A., Thomaz-Soccol V., 2010, The potential of probiotics: a review, Food Technology and Biotechnology, 48(4):413-434.

Spanggaard B., Huber I., Nielsen J., Sick E.B., B. Pipper C.B., Martinussen T., Slierendrecht W.J., and Gram L., 2001, The probiotic potential against vibriosis of the indigenous microflora of rainbow trout, Environmental Microbiology, 3(12):755-765.
https://doi.org/10.1046/j.1462-2920.2001.00240.x

Verschuere L., Rombaut C., Sorgeloos P., and Verstraete W., 2000, Probiotic bacteria as biological control agents in aquaculture, Microbiology and Molecular Biology Reviews, 64(4): 655-671.
https://doi.org/10.1128/MMBR.64.4.655-671.2000

Vijayan K.K., Bright Singh I.S., Jayaprakash N.S., Alavandi S.V., Somnath Pai S., Preetha R., Rajan J.J.S., and SantiagoT.C., 2006, A brackishwater isolate of Pseudomonas PS-102, a potential antagonistic bacterium against pathogenic Vibrios in penaeid and non-penaeid rearing systems, Aquaculture, 251(2-4):192-200.
https://doi.org/10.1016/j.aquaculture.2005.10.010

Wang Y.B., and Xu Z.R., 2004, Probiotics treatment as method of biocontrol in aquaculture, Feed Research, 12: 42-45.

Wang Y.B., Li J.R., and Lin J., 2008, Probiotics in aquaculture: challenges and outlook, Aquaculture, 281(1-4): 1-4.
https://doi.org/10.1016/j.aquaculture.2008.06.002

Zorriehzahra M.J., Delshad S.T., Adel M., Tiwari R., Karthik K., Dhama K., and Lazado C.C., 2016, Probiotics as beneficial microbes in aquaculture: an update on their multiple modes of action: a review, Veterinary Quarterly, 36: 228-241.
https://doi.org/10.1080/01652176.2016.1172132

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