



## **Application of probiotics and prebiotics for sustainable development of aquaculture: A review**

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### **Abstract**

Aquaculture is the wildest developing food-producing subdivisions of the world wide. The world aquaculture has vastly developed through the previous few years, and also attracts an economically significant sector. Like any other production sector aquaculture is also exposed to pressure conditions that induce the aquacultures immune system. Also, some factors increase their vulnerability to diseases. Accordingly, it disturbs both the financial development and socio-economic status of the local people in several developed and developing nations specifically developing nations. The disease regulator strategy in aquaculture production has succeeded by following different approaches expanding traditional methods: artificial chemicals, biological and antibiotics. The practice of antimicrobial drugs and pesticides has directed the evolution of resistant straining of bacteria. Consequently, other techniques are much more vital to maintaining a healthy bacteriological environment in aquaculture production organizations. The recent review précises and deliberates the effects of probiotics and prebiotics direction on growth performance, stress forbearance, intestinal microbiota, immune response, and well-being of aquatic organisms.

**Keywords:** Aquaculture, probiotic, prebiotic, aquaculture

### **1. Introduction**

Aquaculture is the favorable and fastest growing food-producing sectors in worlds wich has biggest potential to accomplish the growing demand for aquatic food (Hodar et al., 2020). Over the past few years, global aquaculture has expanded significantly and developed into an important economic sector. Diseases and the deterioration of

the environment are significant issues in fish farming that cause enormous economic losses due to the rising commercialization and intensification of aquaculture operations (Stentiford et al., 2012).Antibiotics have been utilized traditionally during the past few decades for disease prevention and control, as well as for fish development and competence of feed conversion.

Though, the appearance of microorganisms that are resistant to antibiotics was acknowledged and poses a serious risk to people (Harris et al., 2012). According to, using antibiotics is damaging to aquatic species since it kills favorable microbiota in the Digestive system of fish, and it similarly amasses in their foodstuffs which are unsafe for human consumption. Given these elements, advancements in non-antibiotic drugs are preferable for aquaculture health control (Denev, 2008). Probiotics and prebiotics are dietary supplements that both prevent generalized disease and act as growth-promoting agents. There is a need to conduct additional research on probiotics and prebiotics in aquaculture production since studies examining the use of these nutrients in fish have gotten very slight attention and the data currently available are still inadequate. Research assessing the efficiency of the probiotics and prebiotics in aquaculture have received actual slight attention, and accessible data are still insufficient there is a need to undertake more studies relating to probiotics and prebiotics in aquaculture production systems. The objective of this review is to assemble the current figures proceeding with the use of probiotics and prebiotics in culture fish.

## **2. Probiotics**

Word probiotic means “for life” (Parker, 1974). Probiotics are “Organisms and substances, which contribute to intestinal and microbial equilibrium” (Zorriehzaha, Mohammad alil, et al., 2016). Probiotics are described by Fuller, (1989) as "live microbial feed supplements that advantageously affect the host animal by enhancing its gut microbial balance". Probiotics have been used in aquaculture to increase productivity (El-Saadony et al., 2021), and nutritional value (Alemayehu and Tewodros et al., 2018) to reduce diseases (Irianto and Austin, 2002 and strengthen the immune response capacity of fish (Alishahi et al., 2014).

### **2.1. Probiotic Micro-organisms**

Probiotics are frequently employed as "functional food" for human health in addition to curative,

preventative, and development supplements of aquaculture (Pandiyan et al., 2013). The Gram-positive and Gram-negative bacteria, as well as numerous other species including yeast, bacteriophages, and unicellular algae, are all examples of probiotics (Mukherje, et al 2016). Furthermore, Lactic Acid Bacteria, are Lactobacilli, and Bifidobacteria, which are often found in the intestine of healthy fish, have been extensively employed as probiotic strains, according to Pandiyan et al. (2013) microorganisms reduced into gram-positive and gram-negative categories. The primary gut microbiota is composed of gram-positive bacteria such as Enterococcus, and Streptococcus, which serve as shared probiotic straining (Prasad et al., (2003). And Aquaculture and other animals' digestive tracts are predominately colonized by Gram-negative facultative anaerobes.

### **2.2. Probiotics and Nutrition**

Probiotic microorganisms aid aquatic animals' GIT in both the energy-producing process and the digestion of dietary components (Ring et al., 2018). Rendering to Michael *et al.* (2014), several microorganisms has beneficial outcome on the digestive processes of aquatic organisms. Yang et al. (2019) the enhanced probiotics applications encourage in an Aquaculture area in the digestive microbiota of the fish host, increasing nutrient absorption of the feed and also enhancing the nutritional cost, and strengthening resistant responses to pathogens. The probiotics have a valuable result on the digestive system<sup>1</sup> of fish, because probiotic strains produce extracellular enzymes like proteases, and lipases along with provide growth factors of vitamins and fatty acids (Balcazar, J. L. et al., 2006). Nutrients are absorbed more professionally when the feed is added with probiotics (E. Haroun, et al., 2006). In fish, the reports show that *Bacteroides* and *Clostridium* sp. have donated to the host's nutrition, particularly by supplying fatty acids and vitamins (Peng et al., 2020). *Agrobacterium* sp., *Pseudomonas* sp., *Brevibacterium* sp., *Microbacterium* sp., and *Staphylococcus* species able to contribute to

nutritional processes in *Salvelinus alpinus* L (Ringø, et al., 2018).

### 2.3. Probiotics and water quality

The compounds of Nitrogenous pollution like ammonia, nitrite, and nitrate in aquaculture systems/ponds have a serious concern. The vulnerability of cultured aquatic species to excessively high concentrations of these compounds is mostly species-specific, but in excessive concentrations, these compounds may be extremely destructive and cause mass death in all cases (Ma et al., 2009). Due to this Probiotics reduce the accumulation of the organic load (ammonia, nitrite, and nitrate) and uphold water quality in a well-organized technique. Probiotics recover water quality by changing organic matter into smaller units. The dicentigration of organic matters evolves humble ringredient such as glucose and amino acids that are used as food for beneficial bacteria which decrease accumulation of organic pressure and give well environment to cultivated stock.

*Bacillus* sp. had been developed as an agent to decompose organic material and control bacterial pathogens. *Bacillus* spp., *Saccharomyces* spp., and lactic acid bacteria are probiotic strains that originate in the very few positive benefits of probiotics to water or bottom soil quality. Commercial probiotics are available in liquid and powder form, with the latter being more commonly used in water (Mamun et al., 2019). Organic waste can be converted to CO<sub>2</sub> by probiotic bacteria like *Bacillus* sp., reducing the amount of organic effluent in the aquatic system. The amount of nitrate, nitrite, and ammonia is greatly decreased by the use of nitrifying. These principles of purifying the water in the hatchery enhance larval existence and growth (Moriarty, 1998 Sayesn et al., 2017). Additionally, *Bacillus* sp., another famous probiotic bacteria, is employed to reduce metabolic waste in the aquatic system.

The affluence of different nitrogenous substances including ammonia, nitrite, and nitrate has a significant issue in the aquaculture system, claim

Michael et al. (2014). Certain substances are fatally hazardous when present in large quantities. According to Ma et al. (2009), *Lactobacillus* sp. alongside removes pathogens and nitrogen from contaminated Fish farms. In general, gram-positive microbial are more effective converting organic matter back to CO<sub>2</sub> than gram-negative microbial, which would instead turn organic carbon into bacterial biomass or slime, according to Stanier et al. (1963). *Bacillus* sp. and other aerobic gram-positive bacteria are linked to the improvement of water quality, the decrease in pathogenic populations in the cultural environment, the enhancement of the survival and growth rate, and the better health condition of juvenile *Penaeus monodon* (Ngan and Phu, 2011).

### 2.4. Growth Promoters

Probiotics are used in culture fish to improve the growth of cultivable fish and capacity of organisms to out-grow the pathogens in favor of the host or to recover the growth of the host and but no side effect on the host completes it a probiotic bacteria. Yassir et al. (2002) used probiotics *Micrococcus luteus* microorganisms for development and reported the highest development performance on *Oreochromis niloticus*. Lactic acid microbes are also mentioned as growth promoters due to their essence in the growth rate of juvenile fish (Alishahi et al., 2018). Probiotics additionally upgrade appetite and lead to enhanced growth and better feed conversion and improved digestibility. It determines if probiotics taste good for aquaculture species (A. Irianto and B. Austin, 2002).

The practice of probiotics by way of growing promoters of palatable fishes and the diet of (*Oreochromis niloticus*) was edited with probiotics *Streptococcus* strain, significantly upgrade the amount of crude protein and crude lipid in the fish weight is increased from 0.154 g to 6.164 g in 9 weeks of culture (F. Lara et al., 2003). Because of the commercial importance of fish species, the effect of complementing the diet with probiotics shaped an increase of 115.3% when the commercial formulation was made at a concentration of 2% (E. Haroun, et al., 2006).

Probiotics moreover have been tried effectively in shellfish culture. Macey and Coyne, (2005) isolated two yeasts and one bacterial strain from the digestive tract of abalone (*Haliotis midae*). A diet was formulated with a mixture of the three putative probiotics. The development rate of little (20 mm) and huge (67 mm) abalone was progressed by 8% and 34%, cultures.

## 2.5. Probiotics and Disease Control

A current probiotic organism can simply achieve the needs of maintainable aquaculture development due to the main key factors of growth performance and disease resistance (Dawood MAO, Koshio S, 2016). Their products are beneficial effects on the host's gut defenses and disease prevention in the fish culture system. Probiotic bacteria discharge some biochemical substances in the intestinal tract of the host fish that inhibit the propagation of opportunistic pathogens (Martínez Cruz and Ibáñez, 2012). The controlling of probiotics to minimize the practice of antibiotics and synthetic chemicals in fish food (Dawood Mahmoud et al., 2019).

Probiotics are currently increasing in popularity as valuable microbes candidates in cultured organisms to retain the health condition and happiness of different aquatic animals. The controlling of the gastrointestinal microbiota develops vital meanwhile also guarantees the fight and prevention of diseases, and the digestibility, and absorption of nutrients, resulting in advanced product performance and the prevention of disease of the host (Ferreira, 2014). Probiotic organisms increase the resistance method of culture organisms, improving their disease and preventing the pathogenic organisms from disease formation in the host (Dawood and Koshio, 2016). Most survey probiotic applications in aquaculture consider the ability to inhibit or exclude pathogenic bacteria. The mainstream studies addressing disease resistance use the in vitro assay to classify antagonistic effects as one of the greatest important selection criteria for applicants for the probiotic. According to Kuebutornye et al. (2019), the exercise

of *Bacillus* sp. showed disease protection by introducing cellular and humoral immune resistances in tiger shrimp (*P. monodon*) more or less bacterial and fungal strains were mixed with feeding pellets and enhanced essential microbial flora of the gut (Prasad *et al.*, 2003 and Nageswara and, Babu, 2006). Probiotics like lactic acid bacteria applied in the food of fry of Atlantic cold indicated suitable growth, survival, and immune response (Gildberg A., 1997). According to Prasad *et al.*, (2003) report shows *Lactic Acid Bacteria*, a popular probiotic strain, can be purposeful to control bacterial infection.

Several straining of *Aeromonas*, *Vibrio*, *Streptococcus*, *Yersinia*, *Pseudomonas*, *Clostridium*, *Acinetobacter*, *Edwardsiella*, *Flavobacterium*, white spot syndrome virus, and infectious hypodermal and hematopoietic necrosis virus has proven to be mitigated by *Bacillus* Kuebutornye, Felix KA, et al., 2020).

These probiotic organisms could be used in combination such as the incorporation of the individual supplementation of *Lactobacillus rhamnosus* and *Lactobacillus sporogenes* to enhance the health and disease resistance of common carp (Allameh, et al 2014, Chi, et al. 2014, Faramazi, et al., 2011 and. Harikrishnan. et al., and 2010). It also enhanced the resistance toward the pathogen expressed as a higher survival rate in different aquaculture species including tilapia (the Chu, et al., 2020) carp species (Feng, et al., 2019) rainbow trout (Ghosh, et al., 2016) cod (Puvanendran, et al ., 2021 )and several other species.

## 2.6. Probiotics and Immune Response

Probiotics use in Aquaculture is growing with the mandate for the environment-responsive maintainable aquaculture. The profits of such supplements are probiotics improve feed value, enzymatic contribution to digestion, inhibition of pathogenic bacteria, anti-mutagenic activity improved immune response (Van Hai; Ngo, 2015). According to Michael *et al.* (2014) Among the numerous valuable effects of probiotics,

modulation of the immune system is one of the most commonly purported benefits of probiotics. The reports show that fish larvae, shrimps, and other aquatic animals have immune systems that are dependent mostly on non-specific immune responses for their confrontation with infection. Akhter et al. (2015) demonstrated that oral administration of *Clostridium butyricum* bacteria to rainbow trout improved their resistance to vibriosis by emerging phagocytosis of leucocytes. On indirect, immunostimulation, includes lysozyme, serum peroxidase, alternate peroxidase, phagocytosis, and breathing burst activities. Interestingly, probiotics also motivate the immune response, with an intensification in exact antibody production. These antibodies show a critical role in decreasing the range of spread of pathogenic bacteria to the liver and the spleen after infection with the pathogen. Probiotics are inoffensive bacteria that assist the well-being of the host animal and contribute, directly or indirectly to protecting the host animal against destructive bacterial pathogens (Van Hai; Ngo, 2015).

### 3. Probiotics

Prebiotics are indigestible feed components that motivate the activity of favorable gut commensal organisms in the host thus improving the health of fish (Guerreiro et al., 2016). The feed component which acts as a prebiotic essential possesses the following criteria such as showing resistance to intestinal acidity, hydrolysis by digestive enzyme, fermentation by gastrointestinal microflora, and growth in the abundance of intestinal bacteria associated with health (Das, et al., 2017).

#### 3.1. Prebiotic Organisms

Sugars are the greatest effective prebiotics which could be categorized based on the step of polymerization (Akhter et al., 2015). According to Mahious and Ollivier (2005), several food substances such as non-palatable Sugars, smaller proteins, peptides, and certain fatty acids act as prebiotic constituents. Prebiotic combinations like fructose, mannan oligosaccharides, and B-glucan are considered the greatest operative prebiotics in culture fish (Guerreiro, 2016).

Prebiotics mostly digest dietary fiber or fermentation by *Bifidobacteria*, *Lactobacillus*, and *Bacteroides* (Yousefian and Amiri, 2009).

#### 3.2. Prebiotics and Growth of fish

Prebiotics is made as feed supplements that succeed in enhancing growth performance. Growth factors differ based on aquatic bacteria in addition to prebiotic supplements. The food containing 20 g kg<sup>-1</sup> oligofructose engineered by incomplete enzymatic hydrolysis of inulin, better for the growth of fish species larvae, but 20 g kg<sup>-1</sup> inulin itself did not distress growth (Mahious et al., 2006).

#### 3.3. Prebiotics and fish Health

The prebiotic was a non-consumable feed ingredient which helpfully upsets the host through select inspiring the growth and action of a partial number of microorganisms in the colony. Even though the potential benefits to health and performance as well-known in various terrestrial animals, the use of prebiotics in the farming of fish and shellfish has been less investigated (Ringø, E., et al. 2010 ). According to Yousefian and Amiri (2009), antibiotics regulate bacterial diseases but a kind of chemical substance is sensible to inhibit in culture fish. Aquaculture industry was other policies developed for disease control in addition to the decrease in the widespread usage of antibiotics. Prebiotics are a famous group of these policies which strengthen, non-specific immune responses. The increased interest in food fish consumption, in common with the prohibition of antibiotics for fish growth raise and greater public awareness of healthy fish production, led to an augmented interest in the potential benefit of feeds as health developers. Prebiotics are focused fixings that are made in fish, existence reported to be related to improvements in growth, feed competence, gut microbiota, intestinal enzyme actions, gut morphology, immune position, disease resistance, intermediate metabolism, and stress responses (inêsGuerreiro, 2017).



### 3.4. Prebiotics and Microbes

Prebiotics could change microorganisms of the intestinal tract by developing immune responses (Frei, *et al.* 2015). The digestive tract of all invertebrates and vertebrates aquatic animals plays a vital role in its habitat for unlike kinds of microbes (Das *et al.*, 2017). Several prebiotic oligosaccharides are fermented in the colon where they react to the growth of bacterial populations connected to a well-functioning colon and oligosaccharides are willingly fermented by favorable bacteria and they are not made effectively by pathogenic bacterial species (Yousefianl and Amiri, 2009).

### 4. Constraints in the application of probiotics and prebiotics:

The practice of probiotics and prebiotics receive excessive consideration as a beneficial line in the aquaculture scheme but sometimes due to inadequate information on their modes of action, the application was hampered (Sutriana, 2017). According to Verschuere *et al.*(2000), the practice of probiotics as organic control agents could be preserved as a kind of risk coverage which should not provide any remarkable benefit when the aquaculture is performed below optimal conditions and in the nonappearance of pathogens. Once cultivating the aquatic species, bacterial inhabitants in the gastrointestinal fillings are abundant higher than in the surrounding water (Denev *et al.*, 2009). Injecting probiotics inside aquatic animals has been used to motivate a fish's immune response against bacterial pathogenic disease (Sahoo and Mukherjee 1999). When to inoculate probiotics into aquatic animals, especially into fish species, and to treat a larger number of fish (Tuan *et al.*, 2013). According to Hoseinifar *et al.*, 2016,)Developments of the strategy have been suggested and practiced as an alternative to antibiotic administration in aquaculture of *Lactobacillus lactis* on the hematological parameter of *Acipenser persicus* demonstrated that the number of blood lymphocytes reduces and granulocytes improved. The consequence of prebiotics on fish ***modification of the immune response*** is partial.

In the case of the beluga whale, prebiotics similar to dietary oligofructose didn't show any significant effect on serum glucose, total protein, RBC counts, mean cell hemoglobin concentration, and corpuscular volume, or different enzyme activities like alkaline phosphatase, alanine aminotransferase and serum lactate dehydrogenase(Adel *et al.*, 2016). The effective fructooligosaccharide on haemato-immunological parameters of stellate sturgeon juvenile (Hoseinifar and Seyed Hossein, 2014), after eleven weeks of management, revealed that haemato-immunological levels (RBC, WBC, hemoglobin, hematocrit and lymphocyte levels) were meaning fully advanced, whereas respiratory rupture activity of leucocytes was not significantly developed by the food supplement. Very limited studies have been showing constraints in the practice of probiotics and prebiotics in culture fish systems.

### 5. Conclusion

The application of probiotics and prebiotics has developed a crucial part of aquaculture practices for refining growth performance levels and disease tolerance. Probiotics are imperative in water quality improvement, feed value, increasing growth rates, weight improvement, immune response, and disease prevention of fish. The prebiotic system similarly has numerous helpful effects essentially in disease tolerance and nutrient obtainability to fish. The use of probiotics and prebiotics improves existence and establishment of the live bacterial dietary supplement in the gut tract of the host. The biotic practices are critical for developing the health ranks and the production of fish, in place of more outdated immunological and disease control methods like vaccinations, antimicrobials, and immunostimulants. The difference in growing, and feed consumption, in addition to health benefits with the dietary practice of these biotics, is may be reliant on the fish species, the extent of feeding, and supplement dosage.

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