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Probiotics in aquaculture: a review on recent trends and application

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A B S T R A C T

The aim of the study is to present a contemporary understanding of probiotics and their current uses in aquaculture. For the world's ever-growing population, aquaculture is crucial in ensuring food security and sustainable livelihoods. Aquatic animals face major issues due to the extension, intensity, and diversification of aquaculture practises, including disease outbreaks, decreased output, and threats to the industry's sustainability. Antibiotics have been a long-standing method for controlling fish illnesses as well as for enhancing growth and feed conversion effectiveness. Probiotics have a variety of positive effects, such as enhancing immune responses in hosts, improving water quality, competitively excluding bacterial pathogens by producing detrimental compounds, improving the nutritional status of hosts by producing extra digestive enzymes, growth promotion *etc*. The remedy to this issue is the use of antimicrobial medications, insecticides, and disinfectants in aquaculture disease control and growth promotion. Such supplements include advantages like higher immunological response, improved feed value, and suppression of harmful bacteria. The majority of the probiotic organisms and their function in fish culture are covered in this review's basic sections.

Keywords: Probiotic · Aquaculture · Microorganisms · Residual antibiotics · Bacteriostatic impact

1. Introduction

The cultivation of aquatic creatures known as aquaculture involves intervening in the raising process to increase production and give the stock being cultivated its own identity. In contrast to fishing, this practice enables a targeted rise in the economic production of species for industry, sport fishing, or human food. Aquaculture has developed into a major global economic activity for overfishing of wild populations. Recent decades have seen a prominent increase in aquaculture's contribution to the production of global food, essential raw materials for commercial and pharmaceutical application together with stocking of aquatic organisms for aesthetic commerce.

Aquaculture production practices have been strengthened to a higher extent in both technological and practical methods to fulfil the growing demand of the growing world population [1]. Aquaculture faces numerous challenges of the increased intensification and commercialization of aquaculture production in order to meet demand, including managing water quality and combating diseases and epizootics, domesticating and improving brood stock, developing appropriate feeds and feeding mechanisms, and developing hatchery and grow-out technology. Out of these, disease outbreaks are currently the main obstacles to the aquaculture production of many species, stifling both economic and social progress in many nations.

With an average annual growth rate of 8.9% since 1970, aquaculture is currently the food industry with the fastest global growth. By comparison, catch fisheries have had only 1.2% and 2.8% annual growth, respectively. Conditions for aquatic animals and the ecosystem are harsh by intensifying aquaculture practices [2]. Antibiotics were previously utilised as a conventional strategy for controlling fish illnesses to enhance growth and feed conversion effectiveness. Bacterial cues were one of the new types introduced by probiotics [3]. Probiotic bacteria like *Enterococcus* sp., *Lactobacillus* sp., and yeast like *Saccharomyces cerevisiae* are frequently employed.

Parker first used the term "probiotics" in 1974 to refer to organisms and substances that support intestinal microbial equilibrium. Dr. Elite Metchinkoff was the first to discuss the beneficial role that some bacteria play among farmers back in 1905. So, we can conclude that probiotics are good, healthy, and amiable bacteria [4]. The objective of the work is to provide a modern understanding of probiotics and their contemporary applications in aquaculture.

1.1 Types of probiotics used in the field

Generally three types of probiotics are considered in case of application [5]:

a. Water Probiotics in dry and liquid forms
b. Soil Probiotics of different soil based bacteria like *Nitrosomonas, Nitrobacter etc*.
c. Feed Probiotics including lactic acid bacteria.

1.2 Role of probiotics

By lowering mucosomal and systemic immunity and enhancing physiological and nutritional effects, probiotics improve the host's state of health. These three probiotic bacteria varieties can be used directly on soil, in farming pond water, and as a feed addition. The number of cells in the probiotic that is given with feed is crucial to the survival of animals.

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109 g^{-1} than 1012 g^{-1}. It shows that animals are not protected by higher bacterial counts. Probiotics can also stop bacteria from moving or from crossing the GIT wall, which enhances mucosal secretion by generating immune molecules [6].

1.3 Application of probiotics

1.3.1 Growth promoter

Aquaculture employs probiotics in different paths. They aid in growth accelerating domesticated species. Aquatic food systems are mostly built on phytoplankton (microalgae), which is influenced by probiotics [3]. Probiotic bacteria attach to the intestinal mucosa of fish cultures because they have a higher rate of multiplication than evacuation, which allows them to colonise the gastrointestinal tract. As a growth booster in fish culture, probiotics are also utilised [7]. Probiotic *Streptococcus* strain was added to the Nile tilapia (*Oreochromis niloticus*) diet, considerably increasing the crude protein and crude lipid content in the fish. The weight of the fish also rose, going from 0.154 g to 6.164 g in 9 weeks of culture [8].
Aquaculture can be benefited from the usage of probiotic-possible species to increase growth [9-18].

1.3.2 Inhibition of pathogens

For a very long time, aquaculture employed antibiotics to stop crop illnesses. This led to different concerns, including the residual antibiotics accumulation in animal tissue and an imbalance in the digestive micro biota of aquatic animals, both of which had an impact on the health of those species. Probiotic microorganisms can release chemicals with a bacterial or bacteriostatic impact on pathogenic microbes in the host's intestine, as a prohibitive barrier against the opportunistic growth of pathogens [19].

Increased general immune system responses in *Oreochromis nicoticus*, as shown by factors including lysozyme activity, neutrophil migration, and bacterial activity, improved the fish's resistance to infection [8]. The prospect of a sustainable aquaculture development can easily be met by probiotic organisms as it functions as pathogen inhibition [20-33, 34].

1.3.3 Improvement of feed utilization

A probiotic employed in aquaculture is an active microbial supplement that for fish with good impact on the gut flora while improving feed intake and nutrition [19]. They typically create bacteriocins and organic acids, which prevent pathogens from adhering to aquatic animals' gastrointestinal tracts. *Salmonella* sp. and other harmful bacteria present in the GIT. Gram-positive *Bacillus* sp., *Lactobacillus* sp., and Gram-negative *Pseudomonas* sp. and yeast, fungi are the different representatives of probiotic bacteria that are present in the GIT [13]. An aquatic animal's ability to absorb nutrients is facilitated by this type of bacteria's ability to synthesise enzymes like lipases, all preleased and nutrients, fatty acids, and amino acids [13]. Numerous researches have been conducted on the digestibility of nutrients in aquaculture [7, 13, 17, 30, 35, 36].

1.3.4 Improving water quality

Since Gram-positive bacillus strains generate carbon dioxide by transforming organic matter, they are applied to test the water quality in culture ponds [3]. It is advised to keep ponds' production of probiotics at high levels. Fish farmers decrease build-up of absorbed and particulates organic carbon as a result. Additionally, this may balance out phytoplankton production. In order to keep the water clean and the pond bottom debris removal, other bacteria, such as *Nitrobactor* and *Pseudomonas*, are effective [5]. Probiotics effectively maintain water quality parameters [7,17, 37-39].

2. Overview of probiotics in aquaculture

Comparable to the entire agriculture industry, concerns about sustainability and ecological health are expanding in this much diversified sector. The goal of more sustainable production has long been served by the use of probiotics in aquaculture, but the growth of intensive systems and the effects of climate change present new difficulties. The goal of this effort is to give a summary of the best available research. Multidisciplinary research is required to examine the biological and environmental health implications of the aquaculture industry's steady transition to crop-based feed components, which fundamentally connect the production of aquaculture to terrestrial agriculture.

However, the impact on aquatic species and the ecosystem has increased as a result of intensifying aquaculture practises. Numerous chemicals and antibiotics have been used, resulting in major issues, indirect effects on human health, and even direct effects by breeding bacteria that are resistant to antibiotics. Probiotics provide a sustainable and environmentally friendly alternative to antibiotics and synthetic chemicals in order to accomplish this goal.

3. Research Methods

A thorough analysis of the academic literature was conducted to determine the value of probiotics in aquaculture. Probiotics can be administered in aquaculture in a number of methods, comprising feeding, injection and direct being submerged in water. These probiotic application techniques can be employed singly or in combination in a variety of probiotic formulations, including multistrain probiotics, probiotics with plant extract, and probiotics with yeast extract. Numerous studies came to the conclusion that probiotic use alters enzymes, improving feed utilisation. Probiotic supplementation significantly improves growth performance, which may be attributed to increased release of digestive enzymes that raise hunger, produce vitamins, and break down indigestible substances.

Biological agents having bactericidal or bacteriostatic effects on pathogenic bacteria can be released by probiotic microorganisms. The numerous immune indices of aquaculture animals can be improved by probiotics. Probiotic bacteria can immediately absorb or break down harmful or organic material in the water, enhancing the

quality of water. The stress resistance of aquaculture animals is considerably improved by probiotic supplementation.

4. Results and Discussion

The growth of some unicellular algae, such as *Pavlova lutheri*, is inhibited by huge probiotic bacteria acting as algaecide [8]. Probiotics are applied in prawn larval rearing tanks to increase survival rates over previous larvae in minimum time. Application of probiotic in aquaculture shows signs of improving aqua output [5].

Aditionally, supplying protein-rich food on a global scale, the aquaculture sector plays a typical role in the socioeconomic growth of the nation [5]. The result of the recent global crisis poses pressure to the Government and rising manufacturing costs. Aquaculture is portrayed in this way as a way to satisfy the extending demand for pure water for food or seafood, amplification and diversity of aquaculture, advancements in technological developments for producing food, changes in ecological systems, and alterations in human behaviour, including a greater awareness for protection of bio-diversity, the environment, and public health [40]. Application of probiotics in aquaculture has great potential, but study is still very much needed.

To specify the selection criteria for possible probiotics, it is necessary to comprehend the mechanisms of action. The enhancement of Feed Conversion Ratio (FCR) and Specific Growth Rate (SGR) are additional advantages of probiotics in culture ponds [41]. When probiotics are used throughout the culture, production is better than when a disease break occurs. Probiotics in aquaculture have a very promising future [42]. Despite this, the strains, concentrations, methods of management, and timing of application all affect how well probiotic supplements work.

5. Conclusions and recommendations

Due to the excellent quality animal protein it provides for dietary needs and food security, aquaculture has become best industry with the quickest growth. There lays majority of limitations to this expanding, intensified aquaculture production, including disease outbreaks, stress, deficiency of fish meal as a source of protein, *etc*. Antibiotics and chemical-based disinfectants have historically been employed to treat these issues, resulting in worries about the safety of human and aquatic animal food have been raised, causing environmental pollution. Probiotics, a practical substitute for sustainable aquaculture, heralds a new age in contemporary aquaculture. Probiotics can be utilised to provide the ideal environment for aquaculture animals to flourish and, as a result, improve their health.

The choice of a suitable strain is crucial before using probiotics to increase their efficiency. Only the most potent probiotic at the ideal dosage has the greatest beneficial effect on a given species. The most often utilised technique of probiotic administration in aquaculture is supplementation as feed additives, but the most widely used and practical method is application as water additives. Due to fish's undeveloped digestive systems during the larval stage of development, administration via eating presents difficulties during the early larval stages. Injection also causes significant levels of stress in larval fish. Thus, direct addition of probiotics to the water used for growing animals is realistically appropriate at all phases.

Conflict of interest

The authors declare that there is no conflict of interest in this manuscript.

Data availability

The authors confirm that all data collected or analyzed during this study are included in this published article.

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