Indian Farmer
Volume 10, Issue 11, 2023, Pp. 465-467
Available online at: www.indianfarmer.net
ISSN: 2394-1227 (Online)

Popular Article

Harnessing Beneficial Microbes in Aquaculture

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Received:01/11/2023 *Published:11/11/2023*

Abstract

The growth of aquaculture as an industry has accelerated over the past decades, resulting in environmental damages and low productivity of various crops. The need for increased disease resistance, growth of aquatic organisms, and feed efficiency has brought about using probiotics in aquaculture practices. The first application of probiotics occurred in 1986 to test their ability to increase the growth of hydrobionts (organisms that live in water). Later, probiotics were used to improve water quality and control bacterial infections. Evidence shows that probiotics can improve nutrient digestibility, increase stress tolerance, and encourage reproduction. Commercial probiotic products are made from different bacterial species, including the yeast *Saccharomyces cerevisiae, Bacillus* sp., *Lactobacillus* sp., *Enterococcus* sp., and *Carnobacterium* sp. Stringent management recommendations control their usage.

Keywords: Probiotics, Aquaculture, Pathogens, Nutrient, Water Quality

Introduction

Farming aquatic organisms, known as aquaculture, involves intervening in the raising process to increase production while providing the stock cultivated with private ownership. In contrast to fishing, this practice enables a selective increase in species production for industry, sport fishing, or human food. Aquaculture has developed into a major global economic activity due to the overfishing of wild populations. Recent decades have seen a significant increase in aquaculture's contribution to global food production, raw materials for industrial and pharmaceutical applications, and aquatic organisms for stocking or aesthetic commerce. Numerous fisheries have reached their maximum sustainable levels of exploitation, consumer concerns about the safety and security of their food, market demand for high-quality, nutritious, low-calorie, and high-protein aquatic products, and the fact that aquatic breeding only contributes minimally to carbon dioxide emissions are all contributing factors to this growth rate [1,2].

Intensifying culture systems to suit rising global demand resulted in increased danger of disease outbreaks and significant financial loss for farmers. Strict rules have been created to ban or limit the use of antibiotics in aquaculture due to several negative effects of their prophylactic administration. Over the past three decades, dietary administration of feed additives has drawn more attention as an alternative to antibiotics. The most promising feed supplements for preventing or treating fish and shellfish bacterial, viral, and parasite disorders included probiotics, prebiotics, synbiotics, and medicinal plants [3].

Microorganisms that have positive effects on the host are referred to as probiotics. In light of the advantages of probiotics on humans and poultry, Kozasa made the first empirical application of probiotics in aquaculture [4]. To accelerate the growth of *Seriola quinqueradiata,* a yellow tail, he added *Bacillus toyoi* spores to the meal. Porubcan recorded the usage of *Bacillus* spp in 1991 to assess its potential to boost *Penaeus monodon* agricultural productivity and enhance water quality by lowering ammonia and nitrite concentrations [5,6]. A probiotic shouldn't be categorised as a biological control agent because it may not always be the pathogen's natural opponent [7]. The growth of pathogenic bacteria can, however, be prevented by some probiotics. Moriarty discovered that Bacillus spp. can reduce the amount of Vibrio spp. in prawn ponds, particularly in sediments [8]. Probiotics' capacity to increase hunger, enhance nutritional absorption, and fortify the host immune system has been highlighted in many investigations [9, 10].

Applications of Probiotics in Aquaculture

The need for sustainable aquaculture has encouraged probiotic research on aquatic species. Additional areas have been discovered, such as their impact on reproduction or stress tolerance, albeit this requires more scientific development; the early interest was focused on their usage as growth promoters and to improve animal health.

Enhancer of Growth

Although probiotics have been employed in aquaculture to boost the growth of cultured species, it is unknown whether these foodstuffs stimulate hunger or improve digestibility due to their nature. Some people believe both of these things may be at play; it's also crucial to determine whether probiotics taste good for aquaculture animals

[11]. It has been claimed that probiotics are used to stimulate the growth of edible fish. A probiotic *Streptococcus* strain was added to the Nile tilapia (*Oreochromis niloticus*) diet, greatly increasing the fish's crude protein and crude lipid content. The weight of the fish also rose, going from 0.154 g to 6.164 g in 9 weeks of culture [12]. Due to the commercial importance of this species, using a commercial formulation at a concentration of 2% resulted in an increase of 115.3% when added to the diet [13]. Swordtail (*Xiphophorus helleri, X. maculatus*) and guppy (*Poecilia reticulate, P. sphenops*) are two examples of ornamental fish whose growth has been improved. Their feed has been supplemented with *Bacillus subtilis* and *Streptomyces*, and after 90 and 50 days of administration, *Xiphophorus* and *Poecilia* have significantly increased in growth and survival [14, 15].

Inhibition of Pathogens

Probiotic microorganisms can emit chemicals that have bactericidal or bacteriostatic effects on pathogenic bacteria in the host's intestine, acting as a barrier against the growth of opportunistic pathogens. The creation of antibiotics, bacteriocins, siderophores, enzymes (lysozymes, proteases), hydrogen peroxide, and/or alteration of the intestinal pH brought on by the production of organic acids are generally the causes of the antibacterial effect [16].

Rainbow trout and Atlantic salmon were given live *Carnobacterium* sp. by Robertson *et al*. [17], who also demonstrated invitro antagonistic effects against known fish pathogens *Aeromonas hydrophila, A. salmonicida, Flavobacterium psychrophilum, Photobacterium damselae,* and *Vibrio* species. A combination of *Vibrio fluvialis* A3-47S, *Aeromonas hydrophila* A3-51, and *Carnobacterium* BA211 dead probiotic cultures effectively controls furunculosis in rainbow trout. The observations indicate that cellular immunity rather than humoral mechanisms were responsible for the advantages of these preparations of inactivated bacterial cells in this particular example because the number of leukocytes was higher than with live cells [18]. Studies have concentrated on evaluating probiotics such *Bacillus cereus, Paenibacillus polymyxa,* and *Pseudomonas* sp. PS-102 biocontrol agents against pathogens of various Vibrio species in the case of prawns [19].

Enhanced Nutrient Digestion

According to a study, probiotic strains produce extracellular enzymes like proteases, amylases, lipases and growth factors, including vitamins, fatty acids, and amino acids, which may help aquatic animals digest food more effectively. Probiotics added to the feed improve nutrient absorption efficiency [20]. Probiotics have been employed in fish that can be eaten this way, such as the larvae of the European bass (*Dicentrarchus labrax*).

According to reports, the probiotic yeast *Debaryomyces hansenii* HF1 can create the polyamines spermine and spermidine, which are crucial for the development of the gastrointestinal tract in mammals. Additionally, this yeast secretes trypsin and amylase, which help sea bass larvae digest their food [21].

Enhancing Water Quality

Various investigations monitored water quality when probiotic bacteria were added, particularly those from the gram-positive species Bacillus. This is likely because this particular bacterial species is better than gram-negative bacteria at converting organic materials to Co_2. It is recommended that fish farmers reduce the buildup of dissolved and particulate organic carbon throughout the growing season by maintaining high levels of probiotics in production ponds. Additionally, this may maintain a balance in phytoplankton production [20]. This theory, however, was not supported by experiments utilizing one or more species of Bacillus, Nitrobacter, *Pseudomonas, Enterobacter, Cellulomonas*, or *Rhodopseudomonas* during the cultivation of prawns or channel catfish. Except for nitrification, little published data supports increasing water quality [16].

Tolerance to stress

Aquaculture techniques stress crop species by requiring intensive yields in less time. For instance, persistent stress in zebrafish (*Danio rerio*) has been shown to have a general depressive effect on muscle protein synthesis [22]. As a result, it was sought to use probiotics to boost stress tolerance. One of the earliest published studies in this area examined the effects of adding *Lactobacillus delbrueckii* spp. *delbrueckii* to the diet of European sea bass (*Dicentrarchus labrax*) at intervals ranging from 25 to 59 days. Since the hormone cortisol plays a direct role in the animal's response to stress, it was measured in fish tissue as a stress marker in addition to assessing growth improvement.

Effect on Aquatic Species' Reproduction

Breeding aquaculture species have high nutritional needs. Therefore, their ability to reproduce depends on the right amounts of lipids, proteins, fatty acids, vitamins C and E, and carotenoids, according to Izquierdo *et al.* [23]. Additionally, the interaction of these elements affects reproduction in many processes, including fertility, fertilization, birth, and larval development.

Conclusion

Due to the current global food crisis and rising production costs, authorities and the international community are pressured to guarantee a sufficient food supply for a growing population. Thus, aquaculture is promoted as a solution to the rising demand for freshwater food and seafood as well as to the problems associated with the ongoing globalization of trade, intensification and diversification of aquaculture, advancements in technological innovations for food production, changes in ecological systems, and alterations in human behavior, such as a greater awareness of the need to protect biodiversity, public health, and the environment. These issues will make upgrading aquaculture practices more vital and serve as a viable alternative to the overfishing and ecosystem alteration brought on by capture fisheries. Probiotics can enhance this activity's advantages by providing workable alternatives for forming a higher-quality livestock product in terms of size, production time, and health. It will soon be important to investigate probiotic antibiotic resistance, the potential for genetic element transmission to other microbes in the fish GIT, and ultimately to people when consuming the aquaculture product.

Modern approaches have been used to extract and characterize many probiotic strains found in the GIT of aquatic animals and nitrifying bacteria from biofilters. The diversity found in aquaculture systems is beginning to be revealed thanks to the advent of molecular tools like PCR, FISH (fluorescent in situ hybridization), DGGE (denaturing gradient gel electrophoresis), and the creation of genomic libraries. Phylogenetic identification of probiotic microbes without standard cultivation methods is very promising and made possible by next-generation sequencing procedures.

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