https://doi.org/10.48047/AFJBS.6.12.2024.5598-5612

AFJBS African Journal of Biological Sciences
Journal homepage: http://www.afjbs.com

Research Paper Open Access

Probiotics Contribution to the Development of Aquaculture- A review

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Article History
Volume 6, Issue 12, 2024
Received: 30 June 2024
Accepted: 20 July 2024
Doi:
10.48047/AFJBS.6.12.2024.5598-5612

Abstract:
Globally, aquaculture is the largest and fastest-growing business that produces animal food. Over the past ten years, there has been a minor global decline in fish production, but there has also been a rise in consumer demand for fish products. However, a number of problems are causing this fastest-growing aquaculture sector to lag behind; one of the most significant of these is the prevalence of infectious illnesses, which are crucial to the development of sustainable aquaculture. Historically, the aquaculture system has employed a variety of chemotherapeutic, antimicrobial, or antibiotic medications as treatments or preventative measures to avoid this. However, the application of synthetic chemicals or chemotherapeutics is an extremely expensive operation that has a negative influence on the aquaculture ecology in addition to the industry's socioeconomic losses. In order to produce non-antibiotic, chemical-free, drug-resistant, and environmentally friendly aquaculture, it is imperative to identify the appropriate substitution approach. Probiotics are therefore an alternative to antibiotics and can be used to cure or prevent infectious diseases, improve the microbial balance in aquatic environments, stimulate growth, and strengthen the immune system. Also, it maintains the equilibrium of microorganisms in the gut, minimizing the adherence and colonization of pathogens at various stages, including larval, fry, and juvenile. Probiotics are one method, nevertheless, of fostering and advancing sustainable aquaculture. Probiotics are a useful tool in aquaculture systems, but more research is needed to determine how effectively they work to generate environmentally friendly products and sustainable aquaculture.
Keywords: Probiotics, Sustainable aquaculture, Microorganisms, food security.

Introduction: The fastest-growing and most promising agricultural industry for producing food is aquaculture, which is the economically feasible cultivation of aquatic species in a closed environment. It currently supplies half of the demand for fish products on the world market. The aquaculture industry supports livelihoods, boosts the economies of rural areas, produces pharmaceuticals, is a significant source of animal protein for human consumption, and contributes to the socioeconomic growth of many nations. In order to fulfil the demand for fish worldwide, the aquaculture industry is expanding, intensifying, and diversifying [1]. However, the aquaculture industry has a number of difficulties, including immunomodulation, enhancing pathogen resistance, preventing disease, and boosting growth performance [2]. There are various reasons, such as appropriate pond management, high stocking density, which stresses culturable animals, etc. Infectious illnesses are a major problem in the cultivation of finfish and shellfish, mostly because of intensive aquaculture practices, which result in significant losses for the farmer [3].

Globally, outbreaks of bacterial, viral and fungal, diseases have resulted in catastrophic economic losses. For example, in 1993, China reported disease-related losses of $750 million, and in 1995 and 1996, India reported losses of $210 million [4]. Significant losses occur in rainbow trout aquaculture due to infectious illnesses; according to a recent US trout producer survey, 29.1 million fish were lost in 2018 with infectious diseases accounting for 92% of these losses [5]. However, a disease outbreak has a detrimental effect on aquaculture productivity, which in turn affects many countries' socioeconomic standing [6]. In the last few decades, antibiotics have been utilized not only as a traditional technique for managing fish infections but also to enhance development and feed conversion efficiency [7]. Moreover, the use of antimicrobial drugs leads to the development of antimicrobial resistance in harmful microorganisms [8]. However, antibiotics also cause the beneficial bacteria in the gastrointestinal ecosystem to be inhibited or killed, making antibiotic residue that builds up in fish products dangerous for human consumption [9]. Antibiotics may enter marine habitats through the aquaculture industry and have an impact on the sea surface microlayer, which acts as a reservoir for both antibiotics and bacteria resistant to antibiotics [10]. Antibiotics and other chemicals used in aquaculture have the potential to produce harmful effects, interfere with metabolism and haemolysis, infectivity in hosts with impaired immune systems, and create other adverse effects. The European Union outlawed the use of antibiotics in manufacturing in 2003 due to this problem [11]. The need to meet the worldwide demand for safe food produced from aquaculture has also sparked a hunt for novel dietary supplementing techniques that are sustainable for the environment, environmentally benign, and as effective as antibiotics. A key component of this strategy is lateral DNA transfer. One of the solutions found that can reduce the aquaculture sector's reliance on antibiotics is probiotics [12]. Probiotic products and microorganisms have been shown to help reduce infectious diseases in fish and shellfish aquaculture by boosting the immune system's ability to fight off dangerous infections and promoting the growth of good bacteria in the surrounding environment. Because probiotics have antibacterial, antifungal, and antiviral properties, they aid in the prevention of illness and enhance wellbeing [13]. Numerous probiotic microorganisms, including yeasts, bacteriophages, unicellular algae, and both Gram-positive and Gram-negative bacteria, have been studied for use in aquaculture [14]. Probiotics represent an innovative idea for the aquaculture industry to grow sustainably and securely, and further research is needed to determine how beneficial they are in an aquatic environment. This review paper's primary goal is to use probiotics to advance safer, more sustainable aquaculture practices.

Definition of Probiotics: The word "probiotic" means "in favour of life," and it comes from the lateen terms "PRO" and "BIOS," which are Greek words that together introduced the notion of life, which has been regularly amended since 1965[15]. In the beginning, the term "probiotic" was used to describe "Probiotika," which Lilley and Stillwell (1965) described as a substance or chemicals that promote the growth of other microorganisms [16]. Parker later modified the sentence to read "organisms and substances that contribute to intestinal balance" in 1974.A live microbial feed supplement that improves the microbiological balance in the animal's gut and is beneficial for the host under a variety of high temperatures and salinity fluctuations is included in the definition as revised by Fuller (1992) [17].By using the term "substance," confusion is avoided and the significance of live cells as a necessary component of potential probiotics is acknowledged in this definition. External environmental conditions have an impact on the stability and upkeep of the microbial flora in aquatic species [18]. Additionally, it was proposed that probiotics were a monoculture or polyculture of different microorganisms given to living things, including humans, with the advantage of the host by enhancing the characteristics of native microflora [19]. According to Salminen *et al*. (1999), a probiotic is a microbial preparation or component of microbial cells that has a good effect on the host's health, but it need not be living [20]. The concept of Verschuere *et al.,* (2000) [21] proposed "a live microbial additive that modifies the host and has a beneficial effect on the host" through enhanced feed utilization, enhanced disease resistance in the host, enhanced environmental climate quality, and enhanced ambient microbial population. Probiotics are live bacteria that, when taken in adequate proportions, help the host's health, according to a 1998 hypothesis by Guarner and Schaafsma [22]. Probiotics have been the subject of increased research in the past ten years, it is now understood that these microorganisms alter the gut microbiota, secrete substances that are antibacterial (such as organic acids and bacteriocins), compete with pathogens to prevent their adhesion to the intestine, compete for nutrients that are essential for pathogen survival, and have antitoxin properties. Because of the new finding of a complicated interaction between an aquatic organism and its environment, probiotics are characterized as "water additives". This gave rise to the notion of using probiotics in fish farming to raise the quality of the water by adding them straight into the pond [23]. The most widely accepted definition of probiotics was developed through collaboration between the Food and Agriculture Organization (FAO) and the World Health Organization (WHO): probiotics are live microorganisms that, when given in sufficient amounts, improve the host's health [24]. Many commercial products termed "probiotics" have attempted to capitalize on the theory that microorganisms that improve water quality also improve the health of aquatic creatures. Aquaculture has only lately begun using probiotics, although interest in them has surged due to their potential to reduce disease [25]. Probiotics have been studied and used in aquaculture more often in recent years. The most common microorganisms employed in the production of probiotics include Saccharomyces yeast, microscopic fungus, bacteria from the families *Lactobacillus*, *Enterococcus*, *Pediococcus*, and *Bacillus*.

Criteria of probiotic selection in aquaculture: Since the idea of probiotics is still relatively new, the process of choosing probiotic bacteria has been experimental, with the limited amount of scientific evidence being taken into consideration. Various criteria, including antibiotic susceptibility pattern, toxic generation, metabolic and haemolytic activities, infectivity in immune-compromised hosts, and other side-effects, should be evaluated in this situation [26]. In this regard, it is crucial to realize that the establishment of a sustainable aquaculture ultimately depends on the efficiency of different types of probiotic preparation using different unsuitable microorganisms and their safety in the aquatic environment. Various invitro and in vivo investigations can be used to determine the effectiveness of probiotics and their effects in an aquatic environment [27]. The steps involved in the probiotic selection process are as follows, according de Azevedo, R. V., & Braga, L. G. T. (2012) [28]:

i. The first step is to choose a source of microorganisms (such as the digestive tract of healthy animals).
ii. The microorganisms used for the work are then isolated and given selective cultures to characterize them
iii. After that, a fresh culture is carried out using just the colonies of interest for the invitro assessment (pathogen inhibition, pathogenicity of the target species, host resistance status, and so forth).
iv. In vivo supplementation, as well as small- and large-scale testing, are carried out in the absence of limitations on the usage of the target species to determine whether there is the real benefit to the host.

v. Probiotics that have shown notably positive outcomes can now be manufactured and used on a commercial basis.

Characteristics of good probiotics: Fuller (1989) [29] listed the following characteristics of good probiotic bacteria:

i. Consideration should be given to a strain that can benefit the host animal by promoting growth or enhancing resistance to illness.
ii. it should be non-toxic and non-pathogenic.
iii. They should exist as live cells, preferably in high numbers.
iv. It should be able to survive and metabolize in the gut environment, for example, by being tolerant of low pH and organic acid
v. It should be stable and able to sustain itself for extended periods of time in both field and storage settings.

Function of probiotics: Numerous studies and research papers have revealed the importance of probiotics in the aquaculture industry, including their ability to boost growth, enhance feed digestion, strengthen the immune system, prevent disease, and improve the quality of the water and soil. Different modes of action or characteristics, such as antagonistic activity against the pathogens listed in Table-A, are desired in a possible probiotic.and Fig. A. Cells' capacity to make enzymes and metabolites (such vitamins) [30] (Ali, as well as their capacity to adhere or colonize [31], strengthen the immune system [32].

Probiotics working as Growth Promoter: Probiotics are an essential growth-promoting factor in aquaculture, as experimental data has shown. The use of probiotics in aquaculture reduces the FCR and PER ratio, two important considerations in choosing aquaculture techniques, while enhancing growth and economical production. It's interesting to note that prior research has demonstrated that the pre-digestion of antinutritional components in mixed feed can lead to increased feed utilization in cultured aquatic animals, higher growth and feed efficiency, enhanced digestive enzyme supplementation, and prevention of intestinal disorders [33, 34]. Probiotics have been demonstrated to create growth factors such vitamins, fatty acids, and amino acids as well as extracellular enzymes like lipases, amylases, and proteases. This has a favourable effect on the digestive systems of aquatic animals. evaluated the growth of *vibrio alginolyticus* C7b probiotics in the presence of *Chaetoceros muelleri* microalgae, demonstrating that the two organisms could be grown simultaneously to provide a high concentration that would subsequently be given to shrimp [35]. According to Phianphak *et al.*, 1999 [36], feeding a mixture of *Lactobacillus* sp. isolated from the gastrointestinal tract of chickens for 100 days increased the growth and survival rate of *P. monodon* juveniles. The growth rate of the food fish was enhanced by the use of probiotics. According to Jahan *et al.,* 2021 [37], it has been shown that *Lebeo rohita* growth performance, haematological parameters, and feed utilization was improved by employing *Saccharomyces cerevisiae* probiotics strain. Probiotics have also played a significant role in promoting the growth of shellfish. Probiotics have been shown to control phosphate and nitrogen concentrations, boost shrimp production, and enhance the population density of beneficial bacterial flora [38]. The effectiveness of probiotics is dependent on a number of variables, including the type of hydrobiont, body temperature, the amounts of enzymes, genetic resistance, and water quality.

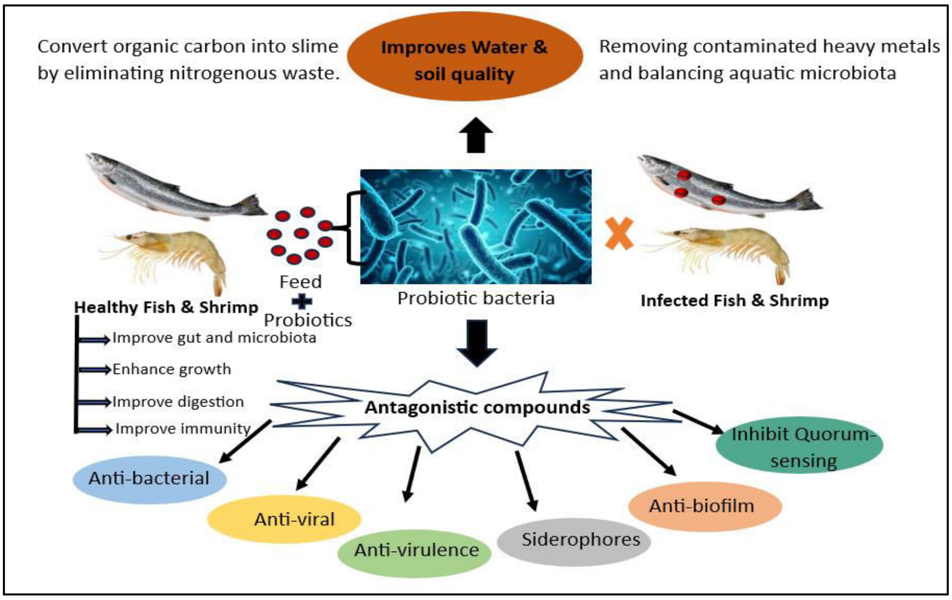
Probiotics action on Water quality improvement: Aquatic organisms raised in water release a variety of harmful gases, including H_2S, and nitrogenous substances, such as NH_3, NO_2, and NO_3. These substances are generally non-specific, but increased concentrations can affect different water parameters, causing disturbances in the aquatic environment and stress conditions, which in turn lead to the death of aquatic animals. Various studies have demonstrated that probiotic strains can enhance the quality of water in this particular setting. It has also been observed that the gram-positive genus Bacillus yields the best results. When converting organic molecules back to carbon dioxide, applying Gram +ve *Bacillus* species is typically more advantageous than applying Gram-ve bacteria. This leads to a higher amount of natural carbon being transformed into microbial activity [39].

Table: 1. Probiotic species and their beneficial effects used in aquaculture

S. No	Probiotic species	Beneficial effects	Reference
1.	*Lactobacillus fermentum*	Better growth, haematological parameters, improved feed utilization	Krishnaveni *et al*., 2021 [40]
2.	*Bacillus amyloliquefaciens Bacillus subtilis Bacillus megaterium*	Increased survival against *A. hydrophila* infection	Saravanan *et al.*, 2021 [41]
3.	*Bacillus subtilis Terribacillus saccharophillus*	Increased growth and immunity	Kalarani *et al*., 2016 [42]
4.	*Bacillus subtilis Lactobacillus rhamnosus*	Enhanced feed digestibility	Munirasu *et al.*, 2017 [43]
5.	*Bacillus amyloliquefaciens*	Improved growth, Immunity and disease resistance	Das *et al*., 2013 [44]
6.	*Bacillus NL 110 Vibrio NE 17*	Increased growth and immunity	Mujeeb *et al*., 2010 [45]
7.	*Saccharomyces cerevisiae*	Increased growth and immunity	Bandopadhyay *et al*., 2015 [46]
8.	*Streptococcus faecium, Lactobacillus acidophilus, Saccharomyces cerevisiae*	Increase growth	Lara-Flores, *et al.,* 2003 [47]
9.	*Bacillus subtilis*	Increase in the growth, survival, improve food digestion, reduce the mortality caused by pathogenic bacteria *Aeromonas hydrophila*.	Ramzani *et al.,* 2014 [48]
10.	*Lactococcus lactis (D1813)*	Produce the most bactericidal activity. Inhibit the *Vibrio penaeicida* infection.	Maeda *et al.,* 2014 [49]
11.	*Lactobacillus plantarum*	Nile tilapia showed improved growth rate, feed efficiency, and immune response when challenged with *Aeromonas hydrophila*. It also inhibited pathogens such as *S.*	Hamdan *et al.,* 2016 Kang *et al.,* 2016 [50, 51]

		aureus, S. typhimurium, S. enteritidis, E. coli O157:H7, *V. ichthyoenteri, S. iniae,* and *V. parahaemolyticus.*	
12.	*Enterococcus hirae*	Persist under simulated gastrointestinal circumstances and inhibit microorganisms such as *Staphylococcus aureus* (MTCC 3160), *Escherichia coli* (MTCC 40), *Pseudomonas aeruginosa* (MTCC 424), and *Salmonella typhi* (MTCC 3215).	Adnan *et al.,* 2017 [52]
13.	*Kocuria sp.* *Rhodococcus sp.*	Produce secondary enzymes that inhibit *Virbio anguillarum, V. ordalii, E. coli, Pseudomonas aeruginosa,* and *Staphylococcus aureus.*	Sharif uzzaman *et al.,* 2018 [53]
14.	*Nitrosomonas species* *Nitrobacter species*	Improves water quality and reduces harmful *Pseudomonas* species bacterial burdens in fish.	Padmavathi *et al.,* 2012 [54]
15.	*Lactobacillus sporogenesis*	Improved growth performance, including total protein, free amino acid, carbohydrate, and fat content, as well as feeding, absorption, conversion, and excretion rates.	Seenivasan *et al.,* 2014 [55]
16.	*Pseudomonas synxantha and Pseudomonas aeruginosa*	Improved Survival and Specific Growth Rate The administration of probiotics increased the number of probiotics in the intestine of prawns and decreased the quantity of bacteria in haemolymph.	Hai *et al.,* 2009 [56]
17.	*Bacillus pumilus*	*Bacillus pumilus*-treated fish have the highest percentage of total erythrocyte count, haemoglobin concentration, and haematocrit concentrations, which increases survival and hence establishes better health circumstances.	Rajikkannu *et al.,* 2015 [57]

Fig. A: Probiotics mode of action. (Modified version) [58,93].



Ngan, P. T. T., Phu, T. Q., 2011 and Dalmin *et al*., 2001, [59,60] state that *Bacillus spp*. is associated with enhanced water quality, reduced harmful pathogenic vibrio species in the surrounding culture environment, increased growth and survival rate, and enhanced juvenile *Penaeus monodon* health. Through affecting the makeup and abundance of the water-borne microbial community linked to farmed species, the effectiveness of aerobic gram-positive endospore-forming bacteria, such as *Bacillus* spp., to improve water quality was assessed [61]. The production of phytoplankton is being balanced by probiotics [62]. According to Lalloo *et al*., 2007 [63], different *Bacillus* strains were obtained and examined from *Cyprinus carpio* in order to enhance water quality in ornamental fish production and prevent *Aeromonas hydrophila* from growing water. One of the nine isolates shown a high ability to inhibit the pathogen with a relative incidence rate of 78% also, ammonia, nitrate, and phosphate concentrations were lowered by 74%, 76%, and 72%, respectively. Probiotics derived from plant sources, such as yucca extract, potassium ricinoleate, tannic acid, and citrus seed extract, as well as some other beneficial bacteria species from the genera *Nitrobacter, Pseudomonas, Enterobacter, Cellulomonas,* and *Rhodopseudomonas*, were also found to have been used in culture systems for improving the water quality [64,65].

Probiotics act as Immune response enhancer: Probiotics can stimulate the non-specific immune system, among other benefits. Microbial adjuncts can limit pathogen formation and promote the growth of cultivated organisms in the gut, skin, and culture [65]. The larval fish, shrimps, and other invertebrates have underdeveloped immune systems compared to adults. Therefore, the resistance of larvae to infection is usually derived from nonspecific immune responses. Probiotic additions to the feed or culture water, however, have been demonstrated in recent studies to enhance the species' non-specific immune responses. *Bacillus* sp. (strain S11) activated both cellular and humoral immune responses in tiger shrimp (*Penaeus monodon*), improving disease resistance, according to Rengpipat *et al.,* (2000) [66].

The larvae of *Scophthalmus maximus* that were fed rotifer enriched with lactic-acid bacteria developed a stronger defence against *Vibrio spp*. infection [67]. By oral introduction of *Clostridium butyricum* bacteria, which raised leucocyte phagocytic activity, rainbow trout's resistance to vibriosis was enhanced [68]. Juvenile shrimp were positively impacted in terms of growth and survival by the injection of a mixture of bacteria strains (*Bacillus* sp. and

Vibrio sp.), which also provided protection against the viruses *V. harveyi* and *white spot virus* [33]. In sea bream (*Sparus aurata*), the co-administration of *Lactobacillus fructivorans* and *Lactobacillus plantarum* in dry or live feed facilitated intestinal colonization and reduced animal mortality during larviculture and foraging [69]. Probiotics generally work by changing cellular variety, boosting immune system function, and preventing the spread of potential infections throughout the digestive system through antibiosis/food and space rivalry [70]. The phagocytic field of activity, serum, and gram-positive S. aureus, which cause orange-spotted infection, are significantly inhibited by the beneficial rod-type microorganism *Lactobacillus* (strains MMI and MM4). Furthermore, the bacteria have been shown to produce hydrogen peroxide and bacitracin-like compounds [71]. Laboratory evaluations of Vibrio sp., peptidoglycan, β-1-3, and yeast glucan on a small scale suggest that these substances may be used as important substances in immunological stimulus-mediated regulation of shrimp infection [72]. Probiotics were anticipated to be crucial in boosting the immune response in shrimp because of their comparatively simple immune system [73]. It has been demonstrated that *B. subtilis* (strains L10 and G1) and *L. plantarum* strains increase gene expression and immune responses in white shrimp (*L. vannamei*). When given to shrimp at 10^{10}cfu probiotics/kg diet, *L. plantarum* enhanced phenoloxidase, prophenoloxidase (proPO), respiratory bursts and superoxide dismutase activity, and clearance efficiency of *Vibrio alginolyticus*. It also improved peroxinectin (PE) mRNA transcription and survival rate following a 168-hour challenge with *V. alginolyticus* [74]. When probiotics were given to shrimp at 10^5 and 10^8 cfu/g, the *B. subtilis* (strains L10 and G1) improved the up-regulation of immune-related genes, including pro-PO, PE, LPS- and β -1,3-glucan-binding protein, and serine protein, following an eight-week challenge with *V. harveyi* [75].

Probiotics working as Stress tolerance: The aquaculture industry is currently using intense farming to meet the global demand for fish, which stresses the species that are cultivated.Aquatic animals are susceptible to temperature changes and other environmental disturbances in addition to pathogen pressure, which can have a negative impact on their physiological status [76].One of the earliest official papers in this subject examined the addition of *Lactobacillus delbrueckii* ssp. *delbrueckii* supplemented at intervals of 25 to 59 days to the diet of European sea bass (*Dicentrarchus labrax*). Since the hormone cortisol is directly related to the animal's reaction to stress, it was measured in fish tissue as a stress marker in addition to assessing the improvement in development. The treated fish's cortisol levels were considerably lower than the control groups [77]. Whether an organism adjusts to altered surroundings and lives or has physiological problems depends on the environmental temperature variation that induces stress [78]. According to Castex *et al.,* (2009) [79], a *Lactobacillus fermentum* strain's anti-oxidative quality might work as a protective mechanism in the gut microbial ecosystem, assisting in the resistance against both endogenous and exogenous oxidative stress (ess).In addition to causing a significantly lower cortisol level and higher HSP 70 gene expression, *Lactobacillus fructivorans* and *L. plantarum* when given to sea bream, *Sparus auratus*, fry using the rotifer, *Brachionus plicatilis*, and *Artemia salina* as a carrier also resulted in a significantly lower cumulative mortality in probiotic-treated sea bream that were subjected to an acute pH stress (from 8.6 to 6.3)[80]. Recent study conducted by several researchers has demonstrated that normal intestinal microflora, which is often consumed as probiotics, influences the animal's protective mechanism by boosting immunity, particularly the putatively beneficial HSP under stressful conditions [81]. Varela *et al.,* (2010) [82] also found that supplementing Sparus auratus' food with the probiotic strain Pdp11 enhances the species' ability to withstand high stocking density stress and promotes growth, indicating a potential benefit to the aquaculture sector. According to the available data, fish may benefit from a probiotic pretreatment prior to undergoing common aquaculture practices that cause stress to animals, such as handling, temperature fluctuations, and frequent handling.

Antibacterial activity of probiotics: Probiotics are often associated with improved gut health because they introduce beneficial bacteria into the digestive tract. It is well known that a number of probiotics used in aquaculture have antibacterial qualities that help prevent certain illnesses. Rainbow trout's resistance to vibriosis was boosted when *C. butyricum* bacteria were added [83]. *Aeromonas hydrophila* is inhibited when tilapia (*Oreochromis niloticus*) is fed *Lactococcus lactis* RQ516 probiotic [84]. *Lactobacillus* has a stronger antagonistic effect against *P. aeruginosa* and *E. coli*, according to [85] Oyetayo, V. O., 2004. *Listeria innocua* could not grow in the intestine of the Spanish mackerel (*Scomberomorus commerson*), which was utilized to isolate lactic acid bacteria. According to Moosavi-Nasab *et al.* (2014), these bacteria included *Lactobacillus acidophilus, Lactobacillus buchneri*, *Lactobacillus fermentum*, *Lactococcus lactis*, and *Streptococcus salivarius* [86]. B. *subtilis* was also found to have significantly decreased the number of motile Aeromonads, assumed Pseudomonads, and overall, Coli-forms in live bearing ornamental fish [87]. Many *Lactobacilli* species isolated from the intestine of Anguilla species, *Clarias orientalis, Labeo rohita, Oreochromis* species, and *Puntius Carnatic* [88] showed significant antibiotic activity against Aeromonas and Vibrio species [88].

Probiotics' Antiviral Action: Some microorganisms are employed as possible probiotics because they possess antiviral qualities. Though it's unclear exactly how these bacteria manage to do this. On the other hand, the in vitro study demonstrates that bacteria can suppress viruses through producing extracellular enzymes. Strains of *Pseudomonas* sp., *Vibrio* sp., *Aeromonas* sp., and *Coryneform* were shown to exhibit antiviral activity against the infectious hematopoietic necrosis virus (IHNV)[89]. When fed the probiotic strain *Bacillus megaterium*, the shrimp, *Litopenaeus vannamei*, are more resistant to the white-spot syndrome virus (WSSV) [90]. Li and colleagues (2009). Applying *Lactobacillus* as a probiotic, either alone or in conjunction with sporolac, increased resistance to the lymphocytic viral disease caused by *Paralichthy solivaceu*s (olive flounder) [91].

Antifungal Activity of Probiotics: Few studies on the antifungal effects of probiotics have been published. *Aeromonas media* (strain A199), isolated from freshwater, showed antagonistic activity against Saprolegnia sp. in an eel (*Anguilla australis* Richardson) culture. Furthermore, it has been discovered that *Aeromonas medium* strain A199 protects fish from *saprolegniosis* [92]. In a different investigation, Pseudomonas species M162, M174, and M169 [93, 94] provided *Oncorhynchus mykiss* (rainbow trout) with increased defence against saprolegnia [94].

Probiotics have potential in aquaculture but In-depth research is required to fully comprehend the probiotics' processes. Probiotics are more effective when used early in the culture process. Probiotics can have a favourable impact on aquaculture animals and the environment. Identifying the bacterium strain and host is crucial for understanding the interaction. Numerous probiotic products have been studied because of their effectiveness in aquaculture. The aquaculture industry now has easy access to species-specific probiotics in the form of beneficial bacterial inocula. These formulations have undergone enhancements to enhance their efficacy as applied probiotics. Furthermore, careful thought should be given to the quality monitoring of probiotic goods. It is anticipated that the use of novel analytical techniques, such as molecular techniques, for in vivo validation and probiotic product assessment will greatly enhance the functional qualities and quality of probiotics.

Conclusion: In conclusion, it's possible that probiotics have unique uses in aquaculture. Probiotics assist the host animals by improving development and nutritional digestibility, boosting disease resistance, and improving the quality of the culture water. Probiotics have been shown to be effective in several reports; nevertheless, the majority of these investigations were carried out and assessed in laboratories. Therefore, in order to adequately assess the use of probiotics, application under culture conditions is required. Species, source, quality, and application techniques in particular will need to be taken into account while assessing the usage of probiotics.

Conflict of Interest: None

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