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Application of Probiotics in Various Preparations in Fish Farming

Aplikasi Probiotik dalam Berbagai Sediaan pada Budidaya Ikan

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Abstract

Fish farming plays a vital role in providing animal protein. Increased production is often hampered by declining water quality, disease, and excessive use of chemicals. The application of probiotics in various preparations is an environmentally friendly alternative to increase production efficiency while maintaining the balance of aquatic ecosystems. This study aimed to examine the effectiveness of probiotic applications in various preparations in fish farming activities. The method used was a literature study. The results of the study showed that probiotics, such as lactic acid bacteria, *Bacillus sp., B. subtilis, B. megaterium, Lactobacillus* sp, *L. casei* and *Saccharomyces cerevisiae* have a positive impact on growth, feed efficiency, endurance, and water quality. Feed quality, environmental conditions, dosage and method of administration, suitability of probiotic strains, and cultivation management influence the effectiveness of probiotics. Selection of the proper preparation and dosage and optimal management of the cultivation environment are the keys to maximizing the benefits of probiotics in increasing productivity and sustainability of fish farming businesses.

Keywords: Fish Farming, Feed Efficiency, Growth, Probiotic Preparation

Abstrak

Budidaya ikan memegang peranan penting dalam penyediaan protein hewani. Peningkatan produksi sering terkendala oleh penurunan kualitas air, penyakit, dan penggunaan bahan kimia berlebihan. Aplikasi probiotik dalam berbagai sediaan merupakan alternatif ramah lingkungan untuk meningkatkan efisiensi produksi sekaligus menjaga keseimbangan ekosistem perairan. Tujuan dari penelitian ini adalah untuk mengkaji efektivitas aplikasi probiotik dalam berbagai sediaan pada kegiatan budidaya ikan. Metode yang digunakan adalah studi literatur. Hasil kajian menunjukkan bahwa probiotik, seperti bakteri asam laktat, *Bacillus* sp., *B. subtilis, B. megaterium*, *Lactobacillus* sp, *L. casei* dan *Saccharomyces cerevisiae* memberikan dampak positif terhadap pertumbuhan, efisiensi pakan, daya tahan tubuh, dan kualitas air. Efektivitas probiotik dipengaruhi oleh kualitas pakan, kondisi lingkungan, dosis dan metode pemberian, kecocokan strain probiotik, serta manajemen budidaya. Pemilihan sediaan dan dosis yang tepat, serta pengelolaan lingkungan budidaya yang optimal, menjadi kunci untuk memaksimalkan manfaat probiotik dalam meningkatkan produktivitas dan keberlanjutan usaha budidaya ikan.

Kata kunci: Budidaya Ikan, Efisiensi Pakan, Pertumbuhan, Sediaan Probiotik

1. Introduction

As a maritime country with the second longest coastline in the world, Indonesia has a portrait of life closely related to aquatic resources (Hayati et al., 2021). This community comprises professional groups such as fishermen, fish farmers and fish traders who directly or indirectly depend on marine and coastal resources (Dimuru 2023). Among these activities, fish farming is a strategic sector providing animal protein whose demand continues to increase along with population growth and global food needs (Ramdhany & Afrianto, 2023). Based on FAO (2022) revealed that aquatic food accounted for about 17% of total animal protein consumption globally in 2019. The contribution reached 23% in lower-middle-income countries and more than 50% in some regions of Asia and Africa. This fact shows that fish farming makes an important contribution in supporting the world's food security.

Despite this, increasing production in fish farming also brings serious challenges. Some of the common problems include deteriorating water quality, high fish mortality due to infectious diseases, and excessive use of antibiotics and chemicals. These practices pose the risk of antimicrobial resistance and pollute the aquatic environment (Pakpahan et al., 2020). For this reason, environmentally friendly aquaculture technology is needed, one of which is the application of probiotics in various preparations to be one of the potential alternative approaches to increase production efficiency while maintaining the balance of aquatic ecosystems (Eliyani et al., 2015)

The application of probiotics in fish farming can be done through various preparations, such as mixing in feed (feed probiotics), direct addition to water media (liquid probiotics). Each preparation has characteristics and advantages that affect its effectiveness in supporting fish growth and health (Syakirin et al., 2025). Various studies have shown that probiotics' dosage and application method significantly affect aquaculture yield. The addition of commercial probiotics in feed at optimal doses, such as 20%, can significantly increase catfish specific growth rate up to 3.96%, feed efficiency, and survival rate (Fadli & Meiyasa, 2023). In addition, the use of probiotics in aquaculture media has also been shown to increase the growth and survival of tilapia with specific optimal doses (Apriyan et al., 2021). However, the effectiveness of probiotics can differ depending on the type of probiotic, dose, application method, and type of fish cultivated (Lestari et al., 2022)

Considering the vital role of probiotics and the variety of preparations available, this review article aims to comprehensively examine the effectiveness of probiotic applications in various preparations in fish farming activities. This review is expected to provide a clear picture of the benefits, advantages, and constraints of using probiotics in fish farming so that it can be a reference for aquaculture businesses in choosing and applying probiotics appropriately.

2. Materials and Methods

2.1. Methods

The research method used was a literature review to assess the effectiveness of probiotic applications in various preparations in fish farming activities. Data and information were collected from various reliable literature sources such as scientific journal articles, theses, books, and research reports that discuss the use of probiotics in fish farming.

3. Result and Discussion

3.1. Definition and Overview of Probiotics

Lilly and Stillwell first introduced the term "probiotic" in 1965 to describe a substance produced by one microorganism that can stimulate the growth of other microorganisms, so this term is the opposite of antibiotic (Ginting et al., 2018). The definition of probiotics then evolved along with scientific understanding of its role. Probiotics as "feed supplementation in the form of live microbes that provide benefits to the host by improving gut microbial balance" (Buruiana et al., 2012).

For application in aquaculture (Verschuere et al., 2000) propose a broader definition, i.e. probiotics as "live microbes that exert beneficial effects on the host by modifying the microbial community associated with the host or its environment, improving feed utilization or nutritional value, promoting host response to disease, or improving the quality of the aquatic environment". Meanwhile, FAO/WHO defines probiotics as live microorganisms that, when consumed in sufficient quantities, can provide health benefits to the host. This definition emphasizes the importance of these microorganisms in living conditions and adequate doses to colonize and provide positive effects, such as improving gut microbial balance, improving the immune system, and improving the quality of the aquaculture environment (Utami, 2023)

3.2. Types of Microbes in Probiotics

Probiotics are microorganisms that are beneficial to cultured fish, playing a role in improving fish health and the quality of the aquaculture environment. Probiotic microbes commonly used in fish farming include lactic acid

bacteria such as *Lactobacillus, Carnobacterium*, several groups of *Bacillus*, and *Pseudomonas* (Hastuti et al., 2020). Here are some types of microbes in probiotics.

3.3. Lactobacillus acidophilus

Lactobacillus acidophilus is a lactic acid bacterium that naturally inhabits the human digestive tract, especially the lower small intestine. These bacteria are gram-positive, rod-shaped, non-spore-forming, and homofermentative, with lactic acid as the main product of carbohydrate fermentation (Gao et al., 2022). Optimal growth occurs at temperatures of 35-38°C and pH 5.5-6.2; at temperatures below 20°C, growth is impaired. Besides being microaerophilic, *L. acidophilus* requires nutrients in the form of glucose and various essential amino acids such as isoleucine, leucine, lysine, as well as vitamins such as calcium pantothenate, and Mn^{2+} ions as growth stimulants (Ningrumsari, 2019). These bacteria are also widely used in fermented products such as yogurt because they have antagonistic properties against *Escherichia coli, Staphylococcus aureus*, and *Salmonella typhimurium* (Sulistijowati & Mile, 2015). *L. acidophilus* can be seen in Figure 1.

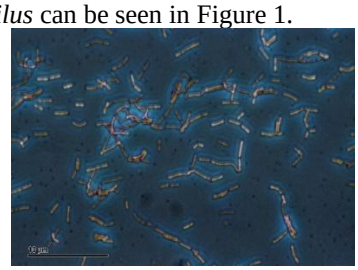

Figure 1. *Lactobacillus acidophilus* (Reischig, 2014)

3.4. Staphylococcus sp

Staphylococcus sp bacteria are gram-positive, non-sporing, non-motile, and facultative anaerobic bacteria with chemoorganotrophic metabolism, which includes respiration and fermentation. This bacterium is catalase positive and oxidase negative, and can convert nitrate to nitrite. *Staphylococcus* sp usually grows on media with a salt content (NaCl) of up to 10%. The primary habitat of this bacterium is the skin and mucous membranes of warm-blooded vertebrates, but it is also often isolated from food products, dust, and water. Some *Staphylococcus* sp are pathogenic to humans and animals (Toelle & Lenda, 2014). *Staphylococcus* sp. can be seen in Figure 2.

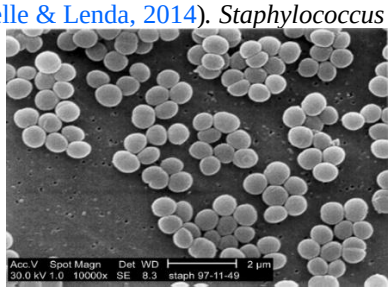

Figure 2. *Staphylococcus* sp (Rosarinargazao, 2007)

3.5. Micrococcus sp

Micrococcus sp bacteria a gram-positive bacterium that can live in the digestive tract of fish and are nonpathogenic, thus providing beneficial effects for fish. This property makes Micrococcus sp potentially be used as a probiotic to prevent disease in fish (Verschuere et al., 2000). Morphologically, *Micrococcus* sp has yellow colony characteristics with a round shape and raised edges. The cells are spherical with a diameter of 0.5-2.0 µm, usually arranged in pairs, small groups, or irregularly, not forming chains. The bacteria are gram-positive, non-motile, catalase-positive, oxidase-negative, and methyl red-positive. The optimum growth temperature ranges from 30-37ºC, and grows well at a NaCl concentration of 1-7% (Putra et al., 2012). Another study also confirmed that *Micrococcus* sp isolated from the digestive tract of catfish (*Clarias* sp) showed effective antibacterial activity, inhibiting the growth of pathogenic bacteria such as *E. coli* and *S. aureus* (Agustiningsih, 2023). *Micrococcus* sp. can be seen in Figure 3.

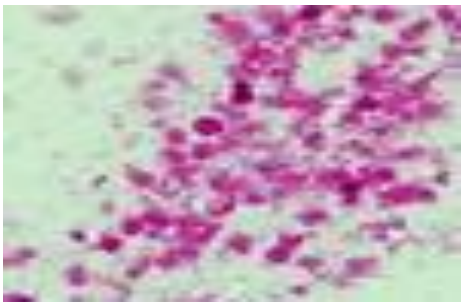

Figure 3. *Micrococcus* sp (Oger, 2007)

3.6. Bacillius sp

Bacillus sp is one type of bacteria that is thought to increase digestibility in fish. According to Fardiaz in Andriani & Pratama (2022), these bacteria produce protease, lipase, and amylase enzymes. Adding probiotics through feed in optimal amounts can produce *Bacillus* sp enzymes contained in probiotics and contribute to the breakdown of complex molecules into simple molecules, making it easier for fish to digest feed. *Bacillus* sp can be seen in Figure 4.

Figure 4. *Bacillus* sp (Joshi et al., 2014)

3.7. Various Probiotic Preparations and Their Characteristics

Probiotics in fish are available in a variety of preparations in both powder and liquid form, with some of the most common including probiotics based on lactic acid bacteria (such as *Lactobacillus* sp, *Bacillus* sp, *Enterococcus* sp) and yeast (*S. cerevisiae*) (Aisyah et al., 2012). Another frequently used preparation is probiotic EM4 (*Effective Microorganisms)*, which contains a mixture of fermentative microorganisms. According to the regulations of the Indonesian Ministry of Marine Affairs and Fisheries (2019), probiotics used in fish farming must contain nonpathogenic microorganisms derived from the aquatic environment or fish body, such as *B. subtilis, Lactobacillus, Nitrosomonas*, and *Nitrobacter*. These probiotics work through bioremediation mechanisms, control pathogenic microbes in the digestive tract, and compete with harmful microorganisms directly. How to use liquid and powdered probiotics on fish can be seen in Table 1.

Table1 . How to use powder and liquid probiotics

Probiotic Preparations	How to use	Source
Powder	- Mixed into fish feed at a concentration of 0.5% by feed weight.	(Tangko et al., 2016)
	- Can also be sprinkled directly into the pond water as much as 1-2 grams / m^3 to improve water quality	
	- Directly mixed into feed at 10 g/kg feed.	(Fadri et al., 2016)
Liquid	- Mixed into pond water at a dose of 5-10 mL/m^3 water	(Umasugi et al., 2018)
	- Sprayed onto feed before feeding to fish at a dose of 10 mL/kg feed.	
	- Sprayed into feed at a dose of 10 mL/feed	(Harmilia et al., 2019)

In research conducted by Nurnaafi et al. (2015) in his research that discusses the probiotic potential of lactic acid bacteria derived from tilapia fish has the results of characterization of NS isolates (5), which are rod-shaped, gram-positive bacteria, do not form spores, catalase negative, non-motile and homofermentative. The following are the advantages and disadvantages of liquid and powder probiotics applied to fish farming, can be seen in Table 2.

Table2 . Pros and Cons of Liquid and Powder Probiotics

Probiotic Preparations	Pros	Disadvantages	Source
Powder	- Longer and more stable shelf life than the liquid form - Effectively increases fish growth, feed efficiency (FCR), and survival rate	- Requires mixing or rehydration for the bacteria to be active and effective in fish digestion - If storage is inappropriate, bacterial viability may decrease - Activation of probiotics may be slower than liquid form after feeding	(Akbar, 2021; Aisyah et al., 2022)
Liquid	- Easy to apply directly to the water medium, improving water quality quickly. - Effectively suppress pathogenic bacteria and improve fish health	- Relatively short shelf life and susceptible to temperature changes and contamination - Needs special handling to keep bacteria alive during storage and application - The addition of large volumes can change the condition of the cultivation water	(Akbar, 2021; Aisyah et al., 2022)

3.8. Mechanisms of Probiotics in Improving Fish Performance

Probiotics are essential in enhancing fish performance through various interacting biological mechanisms. Probiotics improve fish performance through several key mechanisms. First, probiotics produce digestive enzymes such as protease, amylase, and lipase that help break down complex compounds in feed into simpler molecules easily absorbed by the fish, thereby improving digestibility, feed efficiency, and fish growth (Ahmadi et al., 2012). In addition, probiotics create an acidic environment in the digestive tract with the production of lactic acid, which inhibits the growth of pathogenic and spoilage bacteria, thereby maintaining the health of the digestive tract and reducing the risk of disease (Apriyan et al., 2021). Probiotics also stimulate the immune system of fish by increasing the activity of immune cells such as macrophages and antibody production, which strengthens the fish's resistance to infection and environmental stress (Undi et al., 2020). In addition, probiotics play a role in improving the quality of the aquaculture environment by decomposing organic matter and reducing waste accumulation, thereby creating healthier water conditions and supporting fish growth Increased appetite is also reported as an effect of probiotics, which helps increase feed consumption and overall fish growth (Heratri et al., 2024). Andriani et al. (2017) showed that supplementation of commercial probiotics in artificial feed can significantly increase daily growth rate and feed utilization efficiency in sangkuriang catfish fry. The optimal dose of probiotics can increase the activity of digestive enzymes and improve gut microbiota, thus supporting better growth.

3.9. Factors Influencing the Use of Probiotics in Fisheries Activities

The use of probiotics in fisheries is influenced by various interrelated factors that determine their effectiveness. One of the main factors is the quality of feed used in fish farming. Low-quality feed can reduce fish's digestibility, so adding The second factor is the quality and condition of the aquaculture environment, such as temperature, pH, dissolved oxygen levels, and ammonia concentrations that must be maintained within the optimal range so that probiotics can function optimally and fish grow well (Juliyanti et al., 2016). Inappropriate environmental conditions can reduce probiotic activity and cause stress in fish, thus inhibiting growth and increasing the risk of death.

The dosage and method of probiotic administration also greatly affect the success of its use. The correct probiotic dosage and the age of the fish fry at the time of probiotic administration determine the growth and survival of the fish. Probiotic administration can be done through feed or directly into the water medium, and selecting an appropriate method is critical so that probiotic microorganisms can colonize and function optimally in the fish digestive tract and aquaculture environment (Lumbangaol et al., 2024). The success of probiotics largely depends on the ability of the microbial strain to adapt and compete with the natural microflora in the fish gut and the pond environment. Therefore, selecting appropriate and specific strains for particular fish species is highly recommended to obtain maximum results. Overall farm management aspects, including sanitation, fish density, and waste management, also affect the effectiveness of probiotics. Probiotics will be more effective if supported by good management that maintains the balance of the aquaculture ecosystem and minimizes stress on the fish (Telaumbanua et al., 2023)

3.10. Evaluation of the Use of Various Probiotic Preparations in Fish Feeds

The evaluation of various probiotic preparations in fish feed that several authors have carried out can be seen in Table 3.

Table 3 . Evaluation of the Use of Liquid and Powdered Probiotics in Fish Feeds

Types of Probiotics	Type of Fish	Dosage Forms	Research Results	Reference
Lactic Acid Bacteria	Gurame	Liquid	Adding lactic acid bacteria probiotics can cause a specific growth rate of 2.43%, feed efficiency of 27.45%, feed digestibility of 73%, protein retention of 24.70%, and a survival value of 100%.	(Oktaviani et al., 2021)
Lactobacillus sp	Toman	Liquid	The addition of probiotic *lactobacillus* sp can cause an absolute growth rate of 19.22 g and a relative 28.51%, as well as an FCR value of 3.89 and a survival rate of 83-86%.	(Sarmila et al., 2023)
Lactobacillus casei and *Saccharomyces cerevisiae*	Pearl catfish	Liquid	The addition of probiotics containing *Lactobacillus casei* and *Saccharomyces cerevisiae* resulted in daily growth of 6-6.6%, absolute length of 8.4-8.7 cm, absolute weight of 25-27 grams, and FCR of 1.23-1.28.	(Anggana et al., 2021)
B.subtilis and *B. megaterium*	Striped catfish	Liquid	The addition of probiotics containing *B. subtilis* and *B. megaterium* resulted in an absolute weight of 6.54 g, an absolute length of 4.17 cm, and a survival rate of 87.4% at a dose of 0.30 mL/L water.	(Ega et al., 2024)
Lactobacillus sp.	Nila	Powder	The addition of probiotic probio one resulted in an absolute weight of 2.10 g, specific growth rate of 4.42%, survival rate of 98%, and FCR of 1.08.	(Suardani et al., 2023)
Bacillus sp	Toman	Powder	The addition of probiotic *Bacillus* sp resulted in an absolute weight of 1.96 g, an absolute length of 1.88 cm, and a survival rate of 97.5%.	(Prananti, 2022)

Various types of probiotics can be utilized to improve fish health and performance in aquaculture. Probiotics function as live microorganisms that can prevent disease by inhibiting the growth of pathogenic bacteria in fish's digestive tract, thereby increasing fish's immune system and survival (Umasugi et al., 2011). In addition, probiotics also play a role in increasing fish growth by improving digestion and absorption of nutrients through the production of digestive enzymes, resulting in increased feed efficiency (Rahmayanti et al., 2020)

The use of probiotics containing *L. casei* and *S. cerevisiae* can improve aquaculture water quality by decomposing residual feed and organic waste, suppressing pathogens, and reducing feed conversion so that fish growth becomes more optimal (Telaumbanua et al., 2023). Research has also shown that probiotics in carp rearing media significantly increase weight, length, and fish survival (Samsia et al., 2024). In addition to direct benefits to fish, probiotics also play a role in biofloc systems by improving water quality through reducing inorganic nitrogen waste and providing an additional source of feed in the form of microorganisms, thereby reducing feed costs and increasing fish and shrimp production (Ali et al., 2020)

4. Conclusions

Based on the literature review, it can be concluded that applying probiotics in various preparations positively impacts fish farming activities. Probiotics are proven effective in improving growth, feed efficiency, endurance, and the quality of the aquaculture environment. Various factors, including the type of probiotic, dosage, application method, type of fish, feed quality, farming environmental conditions, and overall farming management, influence the effectiveness of probiotics. The selection of the proper probiotic preparation, the application of the appropriate dosage, and the optimal management of the aquaculture environment are the keys to maximizing the benefits of probiotics to increase the productivity and sustainability of fish farming businesses.

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