Fisheries Journal, 15 (4), 1853-1866 (2025)
http://doi.org/10.29303/jp.v15i4.1588

EFFECTIVENESS OF PROBIOTIC, PREBIOTIC, AND SYNBIOTIC APPLICATIONS IN INCREASING FISHERY FARMING PRODUCTIVITY

Efektivitas Aplikasi Probiotik, Prebiotik, dan Sinbiotik dalam Meningkatkan Produktivitas Budidaya Perikanan

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(Received May 25th 2025; Accepted July 23th 2025)

ABSTRACT

Aquaculture is one of the important sectors that fulfill the community's animal protein needs. However, the intensification of aquaculture often faces challenges such as decreasing water quality, increasing disease attacks, and suboptimal organism growth. To overcome these problems, biotechnology-grounded approaches such as the application of probiotics, prebiotics, and synbiotics have begun to be widely developed. Probiotics are living microorganisms that provide health benefits to the host by improving intestinal microflora, while prebiotics are non-digestible compounds that encourage the growth of beneficial microorganisms. The combination of the two, known as synbiotics, is believed to provide a synergistic effect in improving the health and resilience of aquatic organisms. This article reviews various research results related to the effectiveness of the use of probiotics, prebiotics, and synbiotics in improving growth performance, disease resistance, and feed efficiency in various fish and shrimp species. By implementing this strategy, sustainable aquaculture can be realized by strengthening the natural immune system and improving the balance of aquatic microbiota.

Keywords: aquaculture, prebiotics, probiotics, synbiotics

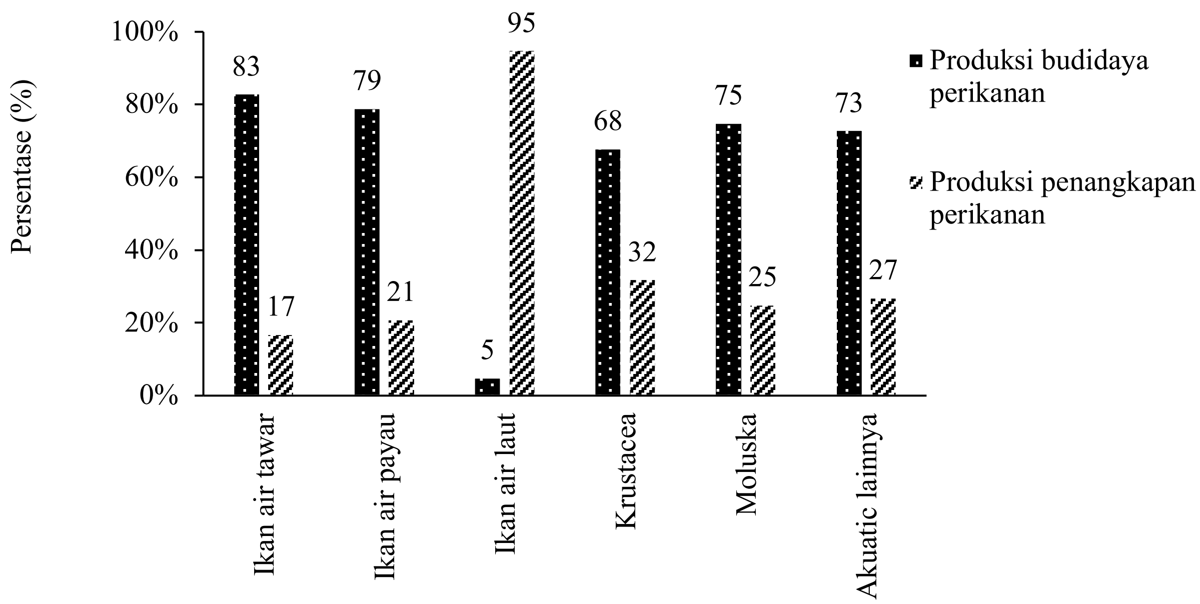
ABSTRAK

Budidaya perikanan merupakan salah satu sektor penting dalam pemenuhan kebutuhan protein hewani masyarakat. Namun, intensifikasi budidaya seringkali dihadapkan pada tantangan seperti penurunan kualitas air, meningkatnya serangan penyakit, serta pertumbuhan organisme yang tidak optimal. Untuk mengatasi permasalahan tersebut, pendekatan berbasis bioteknologi seperti aplikasi probiotik, prebiotik, dan sinbiotik mulai banyak dikembangkan. Probiotik adalah mikroorganisme hidup yang memberikan manfaat kesehatan bagi inang melalui perbaikan mikroflora usus, sedangkan prebiotik merupakan senyawa non-pencernaan yang mendorong pertumbuhan mikroorganisme menguntungkan. Kombinasi keduanya, yang dikenal sebagai sinbiotik, diyakini dapat memberikan efek sinergis dalam meningkatkan kesehatan dan ketahanan organisme akuatik. Artikel ini mengulas berbagai hasil penelitian terkait efektivitas penggunaan probiotik, prebiotik, dan sinbiotik dalam meningkatkan performa pertumbuhan, ketahanan terhadap penyakit, serta efisiensi pakan pada berbagai spesies ikan dan udang. Dengan penerapan strategi ini, budidaya perikanan berkelanjutan dapat terwujud melalui penguatan sistem imun alami dan peningkatan keseimbangan mikrobiota akuatik.

Kata kunci: Budidaya perikanan, prebiotik, probiotik, sinbiotik

INTRODUCTION

Aquaculture in the fisheries sector is a very important industry in providing global food sources, especially animal protein. According to FAO (2024), it shows that aquaculture plays a significant role in fisheries production besides fishing such as fish cultivated in freshwater, brackish water, marine, mollusks, crustaceans (Figure 1). Based on FAO data (2024) in Figure 1, it shows that in fisheries culture production plays a significant role in providing fishery food sources in the world compared to fish capture production from all types of fisheries produced.



Source: FAO (2024)

Figure 1. Aquaculture production and fisheries capture based on FAO data (2024)

Based on these data, it can be concluded that aquaculture plays a significant role in fisheries production. Along with the rapid development of aquaculture, such as for fish and crustaceans, especially shrimp, various health challenges for cultivated aquatic organisms, such as fish and shrimp, are also increasingly complex. These aquatic organisms are often susceptible to disease attacks caused by pathogens such as bacteria, viruses, and parasites. This can cause losses ranging from small to large for the aquaculture industry, such as reduced product quality, and also impact the sustainability of this aquaculture sector in increasing global food production, especially in the fisheries sector. In response to these challenges, the proposed solution is the use or application of probiotics, prebiotics, and a combination of both, or synbiotics, in the world of aquaculture. This has become an increasingly popular approach to improving immunity and the intestinal microbiota of fish and shrimp. Probiotics, prebiotics, and symbiotics are biological components that can improve the balance of the intestinal microbiota, strengthen the immune system, and help aquatic organisms cope with environmental stress and pathogen infection.

RESEARCH METHODS

Place and Time

This research is a literature study or literature review conducted in April 2025 at the Bangka Belitung State Manufacturing Polytechnic. The selection of this location is based on the research conducted which is a literature study or review of several journals related to the title, namely on the advantages of probiotic, prebiotic, and synbiotic applications in increasing immunity and improving the composition of intestinal microbiota in fish farming organisms as well as critically reviewing the substance of the article, research methodology, and the suitability of references to the research topic. Review activities are carried out online and offline according to the schedule and availability of the authors during May 2025 to ensure the quality of objective and in-depth assessment of the submitted manuscript.

Tools and Materials

The materials and tools used by the author in the journal review process include the scientific article manuscript submitted by the author, the assessment guidelines from the editorial board, and supporting literature relevant to the research topic in the form of scientific journals and articles totaling approximately 40 pieces. The author also utilizes scientific databases such as Scopus, ScienceDirect, Springer, Wiley, Taylor & Francis, Sinta, Google Scholar and others to verify the authenticity of the reference sources and the validity of the data used in the article.

Procedure

This research procedure involves several important steps in the preparation of a research article, starting with determining or identifying the topic to be written and then drafting it for publication in a journal. In general, the steps involved in this research are as follows:

1. Determine or identify research topics

Determining or identifying the research topic in this study is an initial and crucial activity because it serves as the initial basis for determining the direction of the search and compiling the literature analysis. This process begins with identifying current or current issues that are developing in fish farming. Researchers can identify topics by observing the latest scientific publications, practical needs in the field, or research gaps that have not been widely discussed. In the field of fish farming, there are several topics that can be raised for research, such as increasing feed efficiency, improving the immune system of fish or cultivated aquatic organisms, and the use of natural ingredients such as probiotic, prebiotic, and synbiotic phytopharmaceuticals, which have become a focus of much study. From here, researchers then formulated a more specific and relevant topic, namely "The Effectiveness of Probiotic, Prebiotic, and Synbiotic Applications in Increasing the Productivity of Fish Farming."

2. Searching for and Collecting Literary Sources

The next stage of this research is to search for and collect literature sources related to the specified topic. This stage begins with the formulation of keywords relevant to the research topic. These keywords are used to search various library sources through scientific databases such as Google Scholar, Scopus, ScienceDirect, PubMed, ResearchGate, or Sinta. After the search process is complete, the researcher selects the literature most relevant to the focus of this research study. Each article or journal found is analyzed based on the article title, abstract, and content to ensure its suitability for the research being conducted. Furthermore, the researcher also compiles an initial bibliography and records important information from each source, including the author, year, study object, methodology, and main results. This process aims to ensure that all information used in the study is sourced from valid, credible literature and supports the predetermined problem formulation.

3. Reading and Analyzing Literature

The next step is to read and analyze the collected literature, beginning with a thorough review of each source. First, researchers read key sections of journals or other sources, beginning with the introduction, methodology, results, and concluding with a discussion. This section aims to understand the context, research objectives, approaches, and key findings of each article. In this stage, researchers must not only understand the text's content but also identify patterns within the articles, differences in results between studies, and factors influencing the success or ineffectiveness of a treatment, such as the type of probiotic used or the cultivation environment. This process will help researchers critically assess the quality and relevance of the information from each source.

After understanding the content of each source, researchers then conduct a comparative analysis between the studies. Information from each article or journal is then summarized in a table or literature matrix that includes key elements such as author, year, study object, treatment, measured parameters, and results. Through this synthesis technique, researchers can draw general conclusions, identify research gaps, and identify consistent trends or tendencies across studies. This analysis is the basis for forming a framework for thinking in writing comprehensive and scientifically valuable literature review results.

4. Drafting a Literature Study Article

The final step in drafting a literature review article is to organize the results of the literature analysis into a systematic scientific writing structure. The researcher then develops a writing framework consisting of an introduction, literature review methodology, results and discussion, and conclusions and suggestions. Furthermore, the researcher must ensure that all citations and references are cited correctly according to applicable citation styles. Using a reference management tool such as Mendeley is very helpful in maintaining consistency in citations and bibliography. After this activity, all sections are compiled, and the draft is revised to ensure coherence between sections, completeness of information, and accuracy of scientific language. The draft article is then checked using a plagiarism checker to ensure originality, and is ready to be submitted to a scientific journal or the target institution.

Data Analysis

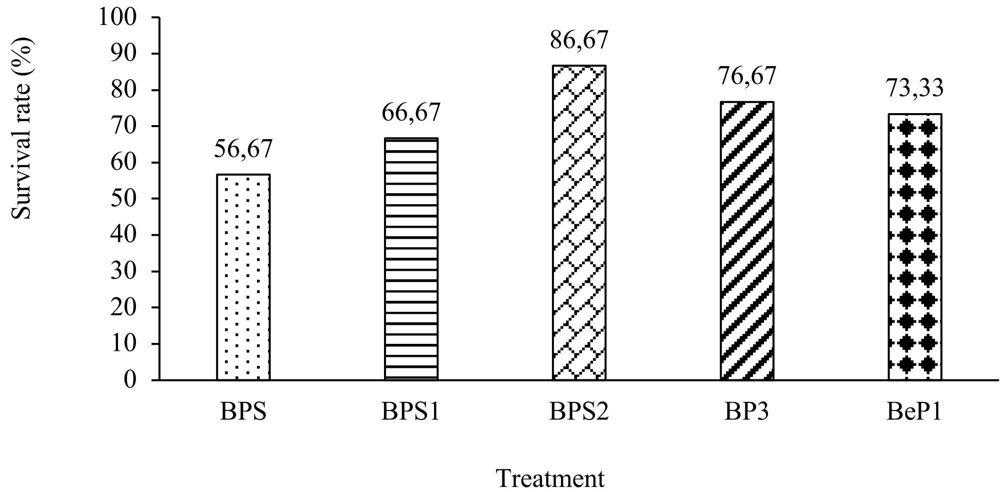
Data analysis in literature studies does not use primary data from experiments, but rather secondary data obtained from various scientific sources such as journals. The data analyzed typically consists of previous research findings, such as specific growth rate (SGR), feed conversion ratio (FCR), survival rate (SR), and the effects of probiotic, prebiotic, and synbiotic applications on the productivity of fish or other cultivated aquatic organisms. Researchers then read, record, and compare these results from each relevant literature source. This step is carried out systematically to obtain a comprehensive and objective overview of the effectiveness of each treatment.

Next, the collected data is organized into a synthesis table or literature matrix to facilitate the comparative analysis process. Researchers can then identify patterns of similarities and differences in results between studies, as well as factors influencing treatment effectiveness, such as fish or other aquatic organism species, application dosage, and maintenance duration. This analysis is descriptive-qualitative in nature, and in some literature studies, quantitative meta-analysis is also possible if sufficient numerical data is available. The results of this analysis serve as the basis for formulating scientific conclusions and recommendations based on evidence from various previous studies.

RESULT

Probiotics

Probiotics are live microorganisms used to provide positive benefits to the health of their host when administered at the correct dosage when consumed. In aquaculture, probiotics are used to improve the health of fish and shrimp through mechanisms such as digestive enzyme production, competition with pathogens, and immune system stimulation (Hoseinifar et al., 2024). Probiotics function by producing antimicrobial compounds such as bacteriocins and hydrogen peroxide, as well as digestive enzymes such as amylase and protease, which aid in feed digestion (Hoseinifar et al., 2024).



Information: PBS (Control), BPS1 (*Staphylococcus edaphicus*), PBS2 (*Bacillus paramycoides*), BP3 (*Bacillus albus*), dan BeP1 (*Bacillus albus*), Sumber: Agustina *et al.* (2022).

Figure 2. Survival rate of kelabau fish seeds after being challenged with *Pseudomonas* sp bacteria.

Wang et al. (2018) reported that administering the probiotic Pseudoalteromonas spp. improved the survival of whiteleg shrimp and suppressed the growth of Vibrio parahaemolyticus. Furthermore, research conducted by Agustina et al. (2022) demonstrated that administering the probiotic Staphylococcus edaphicus to the kelabau fish (Osteochilus melanopleurus) suppressed Pseudomonas sp. infections and increased the survival of the kelabau fish, as seen in Figure 2 and Table 1.

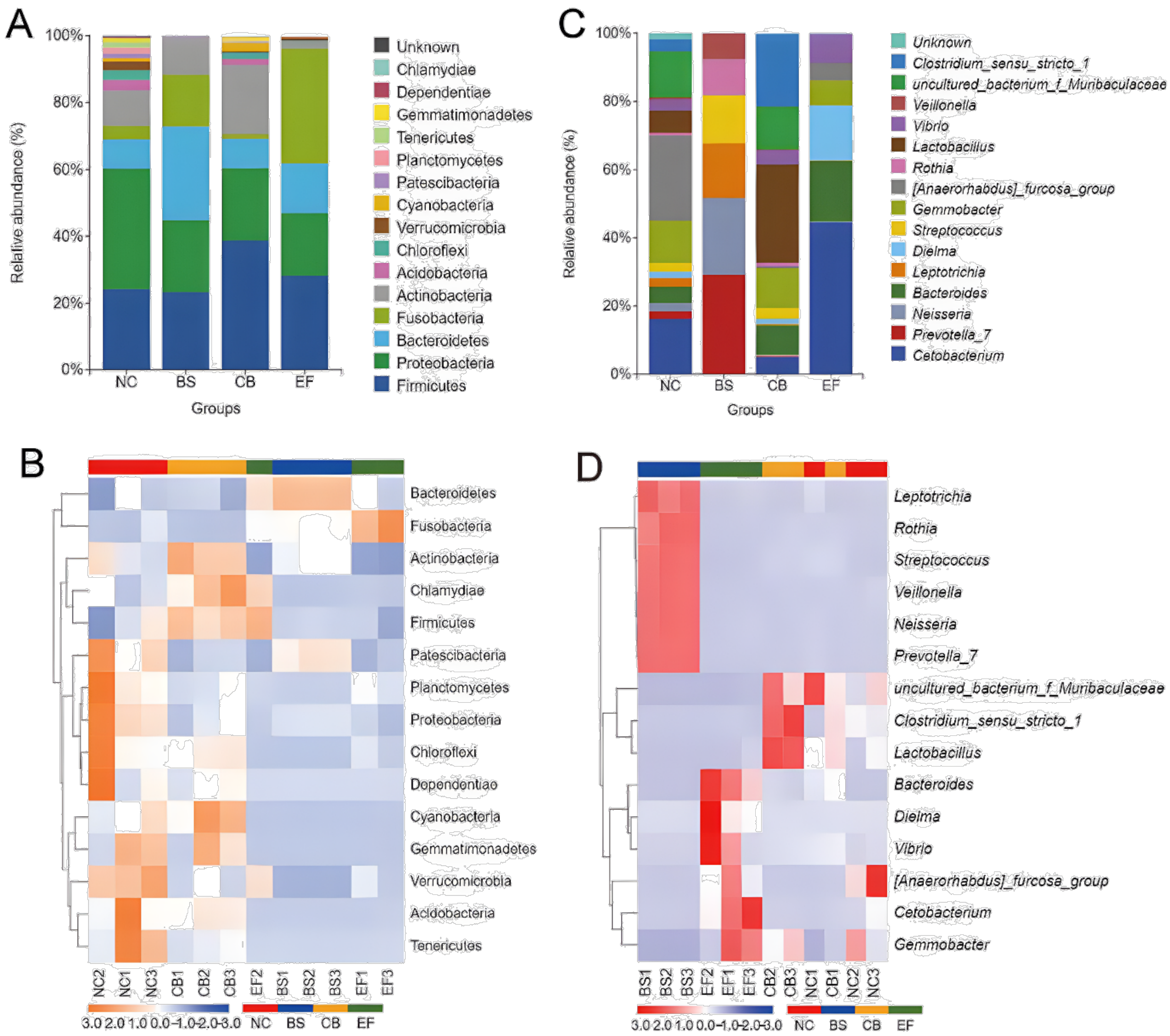
Table 1. Average number of pathogenic bacteria in the blood of kelabau fish after infection with Pseudomonas sp. during observation.

Treatmenr	Number of bacteria in blood (x 10^5 CFU/ml) day to day -			
	15	17	19	21
PBS	18,03±1,58^b	15,75±1,51^b	12,81±1,45^b	11,64±0,57^b
BPs1	14,56±1,02^a	9,74±1,15^a	3,34±0,94^a	1,86±0,37^a
BPs2	14,27±1,26^a	6,23±0,99^a	1,82±0,63^a	1,15±0,74^a
BP3	13,84±1,63^a	9,52±0,88^a	3,18±0,99^a	2,48±0,79^a
BeP1	14,28±0,29^a	7,65±1,79^a	2,71±1,09^a	1,33±0,63^a

Information: PBS (control), BPS1 (*Staphylococcus edaphicus*), PBS2 (*Bacillus paramycoides*), BP3 (*Bacillus albus*), dan BeP1 (*Bacillus albus*), Sumber: Agustina *et al.* (2022).

Furthermore, research conducted by Zhu et al. (2025) by administering probiotics Bacillus subtilis, Clostridium butyricum, and Enterococcus faecalis to grass carp (Ctenopharyngodon idella) showed that it was able to reduce the microbiota from the

Proteobacteria phylum. Then, by administering probiotics Bacillus subtilis to grass carp (Ctenopharyngodon idella), it increased the microbiota of Bacteroidetes and Prevotella. Those given probiotics Bacillus subtilis were able to increase the abundance of microbiota from the Actinobacteria, Lactobacillus, and Clostridium phyla. Those given probiotics Enterococcus faecalis were able to increase the abundance of microbiota from the Fusobacteria, Cetobacterium, and Bacteroides phyla (Figure 3).

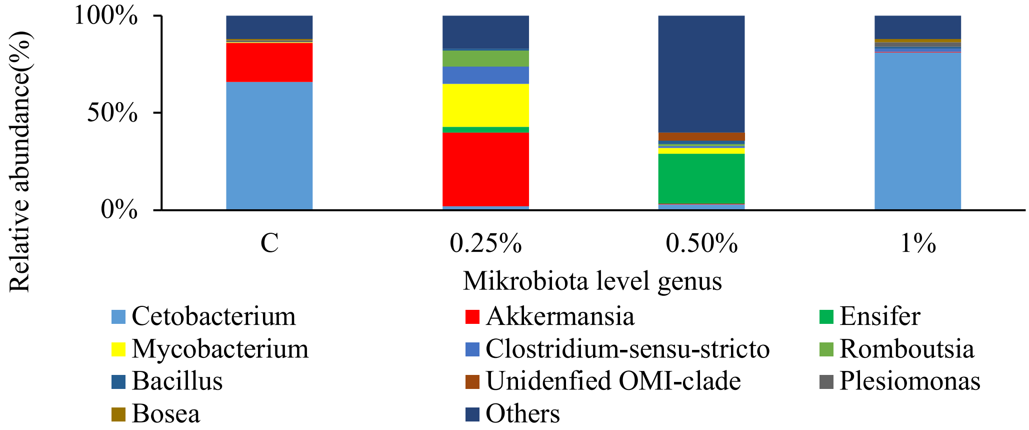


Source: Zhu *et al.* (2025)

Figure 3. Composition of the gut microbiota of Gras fish in various groups given probiotic supplements and the control group. (A) Histogram at the phylum level; (B) Heatmap at the phylum level; (C) Histogram at the genus level; (D) Heatmap of the gut community at the genus level.

Prebiotics

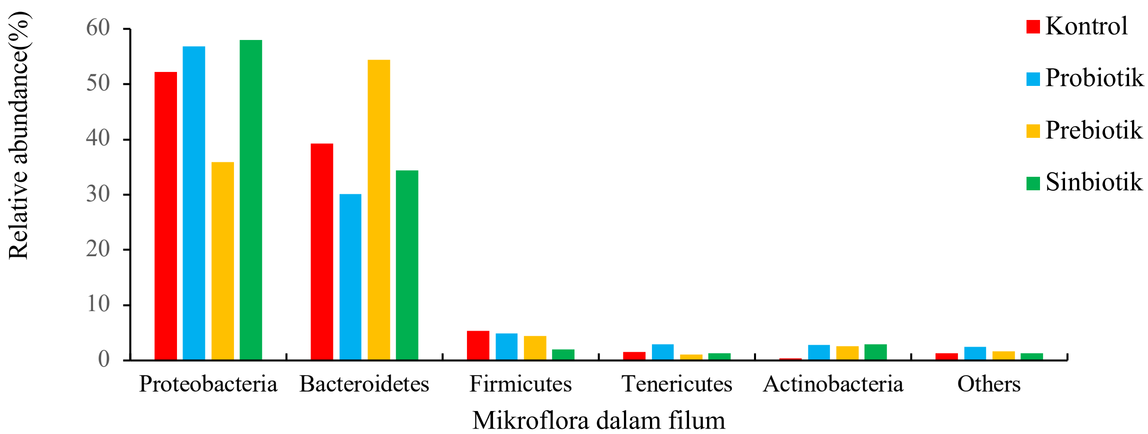
Prebiotics are substances that cannot be digested by the host, but are beneficial for the beneficial microorganisms in the digestive tract. Prebiotics provide a substrate that supports the growth and activity of probiotics, thus creating a healthy microbial ecosystem and supporting more efficient digestion and nutrient absorption. By improving the intestinal microflora, prebiotics play a role in increasing the immune system and digestive health of fish and shrimp (Singh et al., 2024). Research conducted by Rodríguez et al. (2024) showed that shrimp fed feed supplemented with prebiotics showed better feed utilization and growth rates compared to the control group. This is in line with research conducted by Hayimi et al. (2020) which showed increased growth and digestive microbiota in whiteleg shrimp fed honey prebiotics. Furthermore, research conducted by Aryati et al. (2021) showed that tilapia given honey prebiotics can improve growth performance, reduce feed conversion ratio, induce digestive enzyme activity such as amylase, protease and lipase, increase the length of microvilli, the content of short-chain fatty acids such as propionate, iso-butyrate, iso-valerate and N-valerate, and increase the diversity of microbiota in the digestive tract of tilapia which can be seen in Figure 4.



Source: Aryati *et al.* (2021)

Figure 4. Relative abundance of microbiota at the genus level in the digestive tract of tilapia (Oreochromis niloticus) fed with honey prebiotics

Feeding with the addition of honey prebiotics conducted by Aryati et al. (2025) significantly increased the specific growth rate, FCR, and amylase activity, encouraged the development of intestinal microvilli, and stimulated the gut microbiota to improve the gut health and overall vitality of goldfish. The presence of beneficial bacteria, such as Faecalibacterium prausnitzii, is associated with improved gut health and digestion, thus further supporting the health of aquatic species (Rodríguez et al., 2024). Research conducted by Hasyimi et al. (2020), by administering honey prebiotics can increase the microbiota of five dominant microbiota phyla: Proteobacteria, Bacteroidetes, Firmicutes, Tenericutes, and Actinobacteria, with the most dominant being from the Bacteroidetes phylum, as can be seen in Figure 5.

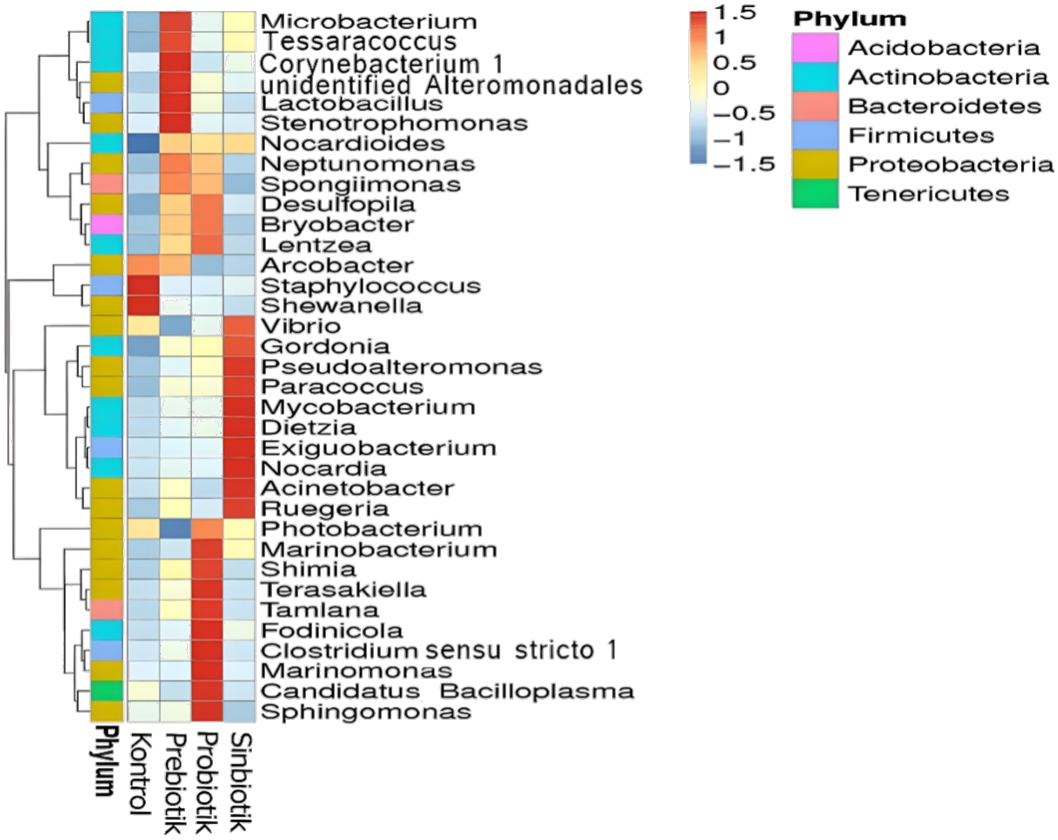


Sumber: Hasyimi *et al.* (2020)

Figure 5. Relative abundance of digestive tract microbiota of vaname shrimp given probiotics, prebiotics, and synbiotics.

Synbiotics

In recent decades, aquaculture has become a crucial sector in the global food supply. However, increasing aquaculture intensity poses various challenges, particularly related to disease, environmental stress, and the overuse of antibiotics. To address these issues, biotechnology-based approaches such as the use of probiotics, prebiotics, and synbiotics are gaining increasing attention. Synbiotics work by increasing the colonization of beneficial bacteria in the digestive tract and preventing pathogen invasion, thus providing a protective effect on the cultured organism (Dawood and Koshio, 2016). Research conducted by Hasyimi et al. (2020) showed that administering a combination of the probiotic Bacillus sp. NP5 RfR and the prebiotic honey (a synbiotic) can improve the intestinal microbiota of whiteleg shrimp, including those of the genera Vibrio, Gordonia, Pseudoalteromonas, Paracoccus, Mycobaterium, Dietzia, Exiguobacterium, Nocardia, Acinetobacter, and Ruegeria, as seen in Figure 6.



Source: Hasyimi *et al.* (2020)

Figure 6. Abundance of microbiota at the genus level in the digestive tract of vaname shrimp given probiotics, prebiotics, and synbiotics.

DISCUSSION

Probiotics

Probiotics can produce antimicrobial compounds that inhibit the growth of harmful pathogens and modulate the host's immune response to optimize infection. They also play a role in improving the integrity of the digestive tract and the balance of the gut microbiota, which are essential for the health and growth of aquatic animals (Wang et al., 2020). Probiotic application can enhance the non-specific immune response in fish by increasing the activities of lysozyme, peroxidase, and immunoglobulin M (IgM), as well as the activity of antioxidant enzymes, namely superoxide dismutase (SOD) and catalase (CAT). This contributes to increased resistance to pathogens (Rahman et al., 2021). Probiotics help maintain the balance of the gut microbiota by inhibiting the growth of pathogens and supporting the growth of beneficial microorganisms. Studies have shown that probiotic supplementation can increase the diversity of microbial species in the gut, which is associated with improved health and growth performance (Wang et al., 2020). Further research has shown that probiotic supplementation such as Bacillus subtilis and Lactobacillus plantarum can improve growth performance, digestive enzyme activity, and immune response in various fish species, including tilapia and grouper (Sokooti et al., 2022; Lin et al., 2024). Furthermore, research conducted by Hutagalung et al. (2023) showed that the addition of probiotics such as Lactobacillus sp. in feed can increase feed conversion, growth rate, and survival of snakehead fish (Channa micropeltes). Then, research conducted by Syakirin et al. (2024), by administering the probiotic Biobac Fish-838 in saline tilapia feed significantly increased biomass growth and feed efficiency. Then, research conducted by Munni et al. (2023) showed that providing feed combined with probiotics such as Bacillus subtilis, Bacillus licheniformis, Bacillus polymyxa, Bacillus pumillus, Bacillus megaterium, Bacillus coagulans, Bacillus amyloliquefaciens, Aspergillus niger, and Aspergillus oryzae can increase protein utilization in feed and specific growth rate in tilapia. Another study conducted by Andriyanto et al. (2014) found that a combination of Lactobacillus sp. and Bacillus sp. probiotics can increase the growth and survival of whiteleg shrimp. Yun et al. (2019) also showed that Sphingomonas sp. probiotics administered to whiteleg shrimp cultivation waters can suppress the growth of Vibrio spp.

Prebiotics

Several previous research results after being combined with food to be given to fish and shrimp showed that prebiotics were able to increase growth, survival, feed efficiency, microbiota composition in the intestine and improve the immune system of shrimp (Li et al., 2009; Zhang et al., 2012; Aktas et al., 2014), as well as fish (Merrifield et al., 2010; Ringo et al., 2010). Several types of prebiotics that have been researched and applied in aquaculture include inulin (Ali et al., 2016; Li et al., 2018), isomaltooligosaccharide (IMO) (Li et al., 2009; Ringo et al., 2010), fructooligosaccharide (FOS) (Hu et al., 2018), mannan oligosaccharide (MOS) (Zhang et al. al., 2012), galactooligosaccharides (GOS) (Nedaei et al., 2019; Mustafa et al., 2019), short-chain fructooligosaccharides (scFOS) (Guerreiro et al., 2016), xylo-oligosaccharides (XOS), transgalactooligosaccharides (TOS), and arabinoxylooligosaccharides (AXOS) (Ringo et al., 2010). Prebiotics such as inulin and fructooligosaccharides (FOS) are indigestible by the host but are utilized by beneficial bacteria, leading to increased microbial diversity and richness in the gut (Singh et al., 2024) (Rodríguez et al., 2024). By cultivating beneficial bacteria, prebiotics help defeat pathogenic species, such as Vibrio sp., thereby increasing disease resistance (Amenyogbe et al., 2024). Another study conducted by Yang et al. (2016) showed that Microbacterium sp. is a candidate probiotic microbiota capable of producing antimicrobials from xantho-oligosaccharides. Huynh et al. (2017) stated that administering probiotics from the genus Lactobacillus can improve growth performance and immune responses in fish and shrimp. Although the benefits of prebiotics are well-documented, it is important to consider that the effectiveness of these interventions may vary based on environmental conditions and the specific microbial communities present in aquaculture systems. Further research is needed to optimize their application for maximum health benefits.

Synbiotics

Synbiotics are a combination of probiotics and prebiotics designed to work synergistically. Probiotics are live microorganisms that, when administered in sufficient quantities, can provide health benefits to their host (Ringo et al., 2018). Prebiotics are non-digestible substrates that selectively stimulate the growth or activity of probiotic microorganisms in the intestine. By combining the two, synbiotics are believed to provide a more potent effect than either administration alone (Van Doan et al., 2020). According to Swanson et al. (2020), synbiotics are defined as a mixture of live microorganisms and substrates that are selectively utilized by the host microorganisms, providing health benefits to the host. In aquaculture, the synbiotic approach is considered more effective than the use of probiotics or prebiotics alone (Widanarni et al., 2020). In the context of aquaculture, synbiotics are used to improve growth performance, increase feed efficiency, enhance immune responses, and maintain the balance of the gut microbiota of fish and shrimp (Hoseinifar et al., 2018).

Oktaviana and Febriani (2023) conducted research on the application of synbiotics with prebiotics from coconut pulp flour to tiger prawns, which provided the best results in terms of increasing daily growth rate, feed conversion ratio, total hemocyte count, and increasing tiger prawn survival. Furthermore, El-Bab et al. (2022) showed that administering a combination of the prebiotic β-glucan (BG group) and the probiotic Bacillus coagulans was able to increase the immunity and growth of tilapia. This combination also increased resistance to Aeromonas hydrophila (El-Bab et al., 2022). Immune responses such as increased lysozyme and neutrophils were observed significantly in the treatment group. On the other hand, Munni et al. (2023) reported that the combination of probiotics with prebiotics improved fish immunity, body metabolism, feed efficiency, and growth performance in tilapia. Research conducted by Giovanni (2019) on providing symbiotics to African catfish by combining fish feed and rearing media can significantly increase the feed conversion ratio and growth rate of African catfish. Research by Xie et al. (2024) on hybrid grouper fish showed that multi-strain probiotic-based synbiotics increased antioxidant activity, gut health, and microbiota diversity.

CONCLUSION

Probiotics, prebiotics, and synbiotics play a crucial role in improving immunity, health, and the gut microbiota of aquatic organisms such as fish and shrimp in aquaculture. Probiotics play an active role in balancing the gut microbiota and enhancing immunity, while prebiotics provide a substrate that supports the growth of beneficial microorganisms. The combination of the two in the form of synbiotics provides a more optimal synergistic effect in strengthening the immune system, increasing feed efficiency, and improving the physiological performance of aquaculture organisms such as fish and shrimp. By improving the balance of the gut microflora, strengthening the immune system, and increasing feed efficiency, the use of probiotics, prebiotics, and synbiotics can not only increase the success of aquaculture but also support the sustainability of the aquaculture industry. Therefore, further research and development in this area is crucial to optimize the potential of probiotics, prebiotics, and synbiotics in aquaculture.

ACKNOWLEDGEMENT

I would like to express my gratitude to all parties who contributed their support and assistance during the preparation of this manuscript. I would especially like to thank the Bangka Belitung State Manufacturing Polytechnic for their valuable guidance and input, the review team for their time in reviewing and providing constructive evaluations, and all colleagues who contributed their assistance in data collection and scientific discussion.

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