Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 7, No.2, April 2025, pp. 02502016-01 ~ 02502016-012
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v7i2.1563

Sustainable Aquaculture: The Role of Probiotic Fortification In Enhancing Catfish Growth In Biofloc Aquaponics Technology

Endah Rita Sulistya Dewi[1*], Ratna Mufidah[2], Reni Rakhmawati[2], Maria Ulfah[2], Nur Khoiri[1], Angelica Tricia Wijaya[2], Noraine Salleh Hudin[3]

[1]Department Magister of Science, Postgraduate, Universitas PGRI Semarang, Jl. Sidodadi Timur No.24 Semarang, Central Java 50232, Indonesia

[2]Department of Biology Education, Faculty of Education, Mathematics, Natural Sciences and Information Technology, Universitas PGRI Semarang, Jl. Sidodadi Timur No.24 Semarang, Central Java 50232, Indonesia

[3]Department of Biology Education, Sultan Idris Education University Malaysia, Universiti Pendidikan Sultan Idris 35900, Tanjong Malim, Perak, Malaysia

*endahrita@upgris.ac.id

Abstract. Catfish (*Pangasius sp.*) is a freshwater fish commodity that is widely cultivated in the Indonesian fisheries sector. The aim of this research was to determine the effect of fortification of liquid probiotics bioprisma and biogan on the protein and fat of catfish meat in the biofloc aquaponics technology. The catfish used in this study was 7-8 cm in size. The research was carried out using a completely randomized design (CRD) method with 3 treatments and 3 replications, the treatments were as follows: P0 = without addition of probiotics, P1 = addition of bioprisma probiotics 0.15 mL/l,5 L of water, P2 = addition of biogan probiotics 0,15 mL/l,5 L of water. The data obtained were then processed and calculated using ANOVA at a 95% confidence interval if a significant effect was found, then continued with Duncan's further test. This study indicates that the addition of probiotic to catfish culture media can affect body protein, body fat, and water quality environmental condition (ammonia, nitrite, nitrate, DO) of catfish. The addition of probiotics in the P1 (addition of bioprisma probiotics 0,15 mL/l ,5 L of water) gave the best effect in increasing the growth of catfish, 18,70% body protein and 8,73% body fat. The integration of biofloc with aquaponics technologies can eliminate geographical limitations and accelerate the urbanization of aquaculture.

Keywords: Aquaculture sustainability, Fish health, Aquaponics, Nutrient retention, Growth performance.

(Received 2025-01-26, Accepted 2025-03-28, Available Online by 2025-04-30)

1. Introduction

Catfish (*Pangasius sp.*) is a freshwater fish that is widely cultivated in Indonesia. popularly consumed in various countries. Catfish is widely consumed because the nutritional content of catfish is 7.51% protein, 6.57% fat and 75.21% water (1). The rapid growth of the freshwater fisheries industry has significantly increased catfish production. The nutritional value contained in catfish makes this fish species used as consumption fish to meet animal protein needs. One of the efforts that can be made to fulfill catfish nutrition is by fortifying additional probiotics that can improve the quality of catfish. Probiotics were used to prevent infections, growth promoters, and improve water quality (2). Bioprisma (CV. Berdikari Sukses Makmur company, Bogor West Java Indonesia) and biogan (CV.KTNA company, Cirebon West Java Indonesia) are types of liquid probiotics that can be used as additional ingredients to maintain the health of catfish. Probiotics are bacteria that are beneficial for fish health. Bioprisma probiotics is a type of probiotic that contains pure, mixed cultures of various microorganisms containing *Lactobacillus sp, Acetobacter, Actinomycetes sp*, nitrifying bacteria, phosphate solvent bacteria, photosynthetic bacteria, active probiotic bacteria and functions to protect fish from the negative effects of waste, while Biogan probiotics, mixed cultures of various microorganisms containing nitrifying bacteria and denitrifying bacteria, can help increase fish resistance to disease and can also accelerate the growth of catfish. The application of probiotics to aquaculture technology, not only because their application is associated with catfish health in cultivated species, but also with the bioremediation in aquaculture systems.

Catfish waste problems can arise due to: 1) increasing organic waste from fish manure, feed and other organic residue; 2) water pollution due to improper catfish treatment; 3) the impact of increased nutrients in water which can cause eutrophication. The problem can disrupt the harmony of aquatic ecosystems and harm other organisms (3). Biofloc technology is a closed aquaculture technology that improves water quality by removing ammonia emitted from aquaculture organisms by using specific microbial communities or by adding extra carbon to the aquaculture systems through an external carbon source in feed (4) (5). Biofloc technology operates by minimizing water exchange while maintaining high stocking density through the principle of decomposing ammonia derived from feces and feed waste using bacteria (6). Biofloc technology could be considered like new strategy for pathogen control, without chemical substances, antibiotics and antifungals, because the feces eliminated by fish are associated with beneficial microbiota, which released to enriched system culture with a carbohydrate source allows their proliferation, resulting a competitive exclusion effect over pathogen bacteria versus natural probiotic bacteria (7).

Optimizing the nutritional quality of fish can also be done by maintaining water quality and raising fish in accordance with fisheries cultivation standards. Problems in raising catfish can be overcome by implementing an environmentally friendly biofloc aquaponics technology in cultivation. The biofloc aquaponics technology is a fish rearing system that converts organic compounds into inorganic ones to grow microorganisms. According to (8)(9) biofloc technology is a technology used to improve water quality in cultivation by balancing carbon and nitrogen in the system. Research by (10) states that the advantages of implementing biofloc aquaponics technology include low water changes (efficient in water use), not depending on sunlight, higher stocking density (up to 300 fish/m^3), high productivity, nutritional efficiency, land use efficiency, less waste, environmentally friendly.

2. Methods

Catfish (*Pangasius sp.*) a number of 600 catfish, 1 month old, 7-8 cm in size and weighing ± 5 g, which were placed in an biofloc aquaponic technology pond with a diameter of 200 cm (up to 300 fish/m^3). The research was carried out using a completely randomized design (CRD) method with 3 treatments and 3 replications; the treatments were as follows: P0 = without addition of probiotics, P1 = addition of bioprisma probiotics 0.15 mL/l,5 L of water, P2 = addition of biogan probiotics 0,15 mL/l,5 L of water. The data obtained were then processed and calculated using ANOVA at a 95% confidence interval if a significant effect was found, then continued with Duncan's further test. This study indicates that the addition of probiotic to catfish culture media can affect body protein, body fat, and water quality

environmental condition (ammonia, nitrite, nitrate, DO) of catfish. Precipitate the bioprisma probiotics that have been added to pond P1 and settle the biogan probiotics that have been added to pond P2, for 5 days. Catfish feed is given twice a day at around 07.00 am and 05.00 pm, the amount of feed is adjusted to the amount of daily feed consumption. Furthermore, protein and fat tests were carried out after three months of maintenance. The protein concentration test was carried out using the Kjeldahl method. Fat testing is carried out using the Soxhlet method.

2.1. Data Analysis and Interpretation

The homogeneity test is used to determine whether the data from two variables in each sample group is homogeneous or not and the ANOVA test is used to compare population means to determine significant differences in two or more groups of data and is used as an analytical tool to test research hypotheses. The following is the ANOVA table for completely randomized design (CRD).

3. Results and Discussion

Data on Body Protein and Fat of Catfish

3.1 Body Protein

The average test for the body protein of catfish is shown in the table 1. It can be seen that the protein test of catfish meat given bioprisma probiotics P1 resulted in the highest protein : 8.70%, P0 : 17.12%, and the lowest result in the P2 : 10. 95%.

Table 1. Body Protein of catfish

Treatment	Repetitions			Total Treatment	Average	Standard (gr)
	1	2	3			
P0	17,67	19,10	14,59	51,36	17,12	
P1	16,65	20,56	18,89	56,10	18,70	17
P2	11,78	10,85	10,21	32,84	10,95	
General total				104,30		
General average					15,59	

Description :

P0 = no probiotics

P1 = 0.15 mL bioprism probiotics/1.5 L of water

P2 = 0.15 mL biogan probiotics/1.5 L of water

The homogeneity test regarding the protein of catfish meat given bioprisma liquid probiotics and biogan probiotics in the biofloc aquaponic technology is presented in Table 2.

Table 2. Catfish Body Protein Homogeneity Test

	Levene Statistic	df1	df2	Sig.
Mean	1.358	2	6	.326
Median	.610	2	6	.574
Median and with adjusted df	.610	2	4.159	.586
Trimmed mean	1.300	2	6	.339

The sig value obtained. 0.326 > 0.05 at the probability level, which means that the three bioprism and biogan liquid probiotic fortification treatments on the protein of catfish meat in the biofloc

aquaponic technology system have the same variance (homogeneous). Calculation homogeneity of variance, then an analysis of the CRD variance is carried out which is presented in Table 3.

Table 3. CRD Variant Analysis for Protein

Type of Diversity	Degrees of Freedom (db)	Sum of Squares (JK)	Middle Square (KT)	F_{count}	F_{table}
Treatment	2	1.079,12	539,56	165,51*	5,14
Galat	6	19,56	3,26		
Total	8	1.098,68			

Description: *Significantly different = $F_{count} \geq F_{table}$ (5%) KK = 0.272%

Analysis data of CRD are presented in table 3. obtained the results of F_{count} (165.51) > F_{table} 5% (5.14), based on the calculation results and ANOVA results, it can be concluded that bioprisma and biogan liquid probiotic fortification have a real effect on the protein of catfish, therefore the Duncan test was carried out to find out how big the difference between treatments is presented in Table 4.

Table 4. Duncan Test for Catfish Protein

Treatment	Average Results	Duncan Test Value 5%	The average difference in value of each treatment		
			P2	P1	P0
P1	18,70 c		-	-	-
P0	17,12 b	3,605	-	1,58*	-
P2	10,95 a	3,737	-	7,75*	6,17*

Description: *= Significantly different at the 5% level

The results of the Duncan test were then calculated between the mean and the treatment, P1 compared with P2, the result was (7.75) which was greater than the 5% Duncan test (3.737), so the observed effect was significantly different. Treatment P1 compared to P0 obtained a result of (1.58) which was smaller than the Duncan test 5% (3.605) so the observed effect was not significantly different. Treatment P0 compared to P2 obtained a result of (6.17) which was greater than the Duncan test 5% (3.737) then the observed effect is significantly different.

3.2. Body Fat

The results of the body fat test for catfish are shown in the table 5.

Table 5. Body Fat of catfish

Treatment	Repetitions			Total Treatment	Average	Standard (gr)
	1	2	3			
P0	1,99	1,63	1,73	5,35	1,78	
P1	11,80	5,37	9,03	26,20	8,73	6,6
P2	17,44	3,15	1,43	22,02	7,34	
General total				53,57		
General average					5,95	

Description :

P0 = no probiotics

P1 = 0.15 mL bioprisma probiotics/1.5 L of water

P2 = 0.15 mL biogan probiotics/1.5 L of water

It can be seen that the test results for catfish meat fat given bioprisma liquid probiotics and probiotics in the biofloc aquaponic technology yielded the highest results in P1 with the highest average amount of 8.73%, followed by P2 with the highest average amount. an average of 7.34%, and the lowest yield is P0 with an average of 1.78%..

The homogeneity test regarding the body fat of catfish is presented in Table 6.

Table 6. Test of homogeneity of variances Catfish Body Fat

	Levene Statistic	df_1	df_2	Sig.
Mean	5.074	2	6	.051
Median	1.774	2	6	.248
Median and with adjusted df	1.774	2	2.394	.337
Trimmed mean	4.772	2	6	.058

The sig value obtained. 0.051 ≥ 0.05 at the probability level, which means that bioprisma and biogan liquid probiotic fortification treatments on the body fat of catfish in the biofloc aquaponics technology have the same variance (homogeneous). Calculation homogeneity of variance, then an analysis of the CRD variance is carried out which is presented in Table 7.

Table 7. CRD Analysis for Fat

Type of Diversity	Degrees of Freedom (db)	Sum of Squares (JK)	Middle Square (KT)	F_{count}	F_{table}
Treatment	2	81,12	440,54	13,69*	5,14
Error	6	192,95	32,16		
Total	8	274,07			

Description: *Significantly different = F count > F table (5%) KK = 0.1712%

The CRD variant analysis data presented in table 7 obtained results F_{count} (13,69) > F_{table} 5% (5.14). Based on the calculation results and ANOVA results, it can be concluded that the liquid probiotic fortification of bioprisma and biogan has a significant effect on the fat of catfish, therefore the Duncan test was carried out to determine how big the difference between the treatments is presented in table 8.

Table 8. Duncan Test for Fat of Catfish

Treatment	Average Results	Duncan Test Value 5%	The average difference in value of each treatment		
			P2	P1	P0
P1	8,73 c		-	-	-
P0	1,78 a	6,54	5,56*	6,95*	-
P2	7,34 b	6,78	-	1,39*	-

Description: *= Significantly different at the 5% level

The results of the Duncan test were then calculated between the mean and the treatment, namely P1 compared with treatment P0, the result was (6.95) which was greater than the Duncan test 5% (6.54), so the observed effect was significantly different. Treatment P1 compared to P2 obtained a result of (1.39) lower than the Duncan Test 5% (6.78) so the observed effect was not significantly different. Treatment P2 compared to P0 obtained a result of (5.56) lower than the Duncan Test 5% (6.54) then the observed effect is not significantly different.

3.3 Water Quality Environmental Condition

The water samples tested for ammonia, nitrite, nitrate and DO are presented in Table 9.

Table 9. Water Quality Environmental Conditions

Water Quality	Treatment			Standard (mg/L)*
	P0	P1	P2	
Ammonia	0,054	0,027	0,070	< 0,01
Nitrite	0,002	0,007	0,006	< 1
Nitrate	6,00	7,20	7,20	20
DO	7,50	8,55	8,25	≥ 3

Source: *SNI 7471.5 Indonesia & National, (2009)

Water quality testing to measure the content of ammonia, nitrite, nitrate below the quality standard and DO above the quality standard.

3.4 Body Protein

The results of the research on the protein of catfish treated in the biofloc technology aquaponic system respectively were P0 of 17.12%. P1 is 18.70% and P2 is 10.95%. The results of the analysis of variance show that the liquid probiotic fortification of bioprisma and biogan has a significant effect on the protein of catfish where F_{count} (165,51) > Ft_{able} 5% (5.14). The results of the protein has been carried out are in accordance with the results of the proximate analysis of catfish meat carried out by (11), where the protein of catfish ranges from 7.59-12.94%. According to (12), catfish has a protein of 14.53-16.1%, and according to (13) that the nutritional value of catfish protein is 12.6–15.6%. It can be said that the liquid probiotic fortification of bioprisma and biogan has a significant effect on the protein of catfish because, P1, the protein produced is 18.70%. P2 protein produced was 10.95%. The average results of the research are presented in table 1. It can be seen that the highest protein in catfish meat was obtained in treatment P1. This data states that the protein of catfish in ponds given bioprisma liquid probiotics obtained a higher percentage compared to treatments without probiotics and treatments given biogan liquid probiotics.

Testing the protein of catfish meat in P1 had the highest protein, this was due to the composition of the bacteria contained in bioprisma probiotics, among others, *Lactobacillus sp*, *Actinomycetes sp*, nitrifying bacteria, phosphate solubilizing bacteria, photosynthetic bacteria, deodorizing substances, decomposing substances for various organic compounds in waste water and fat (14) .Bacteria *Lactobacillus sp* yeast are lactic acid bacteria found in probiotics. Lactic acid bacteria are microorganisms that can live in acidic environments. This bacteria is included in the category of heterofermenting lactic acid bacteria because apart from producing lactic acid it also produces acetic acid, succinic acid, CO_2, bacteriocin which can act as an antimicrobial agent. These bacteria can support the digestive system in the body and so that growth is optimal (15).

The nitrifying bacteria contained in bioprisma probiotics play an important role in maintaining pond water quality, the accumulation of waste in the form of organic materials such as unconsumed feed and metabolic waste that is not completely decomposed. The organic compounds, especially NH_3 and NO_2 which is toxic and dangerous for fish. Based on the research results of (16) in measuring the total organic matter in shrimp pond waste, the addition of the bioprisma probiotic reduced the total amount of organic matter by 91.7% from the original concentration of 87.74 mg/L to 7.27 mg/L in 72 hours.

Biogan probiotics contain Nitrosomonas and Nitrobacter bacteria. According to (17), Nitrosomonas are bacteria that play a role in the oxidation process of ammonia to nitrite in the nitrogen cycle. Ammonia compounds will be oxidized to nitrite and then to nitrate in a process called nitrification. This process is carried out by Nitrosomonas and Nitrobacter.

Treatment P2 has a protein of 10.95%, which is very different from P0 which has a protein of 17.12%. The low protein in the P2 could be caused by the nitrite. The nitrite in P2 was greater than P0. The nitrite

in pool P2 is 0.006 while in pool P0 the nitrite is 0.002. The increase in nitrite in the rearing environment is thought to originate from fish metabolic processes, such as feces and urine. The decrease in protein levels in P2 is thought to be related to the increase in the wet weight of catfish in P2, because the weight of catfish and protein of catfish are mutually continuous. According to (18) protein is a substance that builds muscle tissue and meat, as well as hormones and enzymes that play a role in the growth process. However, protein requirements will decrease with increasing fish weight.

There are several things that need to be considered for successful cultivation, such as the physical and chemical parameters of the water. Catfish metabolism is directly proportional to water temperature. In general, fish metabolism is closely related to temperature or water temperature (19). The higher the temperature, the higher the metabolic rate. The temperature of the catfish pond during the study ranged between 29-30°C. The temperature in this study was still within the normal range for rearing catfish. The optimum temperature range for keeping catfish is 27-32ºC (20). Hyperglycemia will have a bad impact on fish resulting in an increase in cortisol levels in the blood due to stress which will mobilize blood sugar from reserves stored by the body into the blood, so that blood sugar increases. The increase in blood sugar levels is necessary for the process of improving balance during stress, but the energy needs from sugar will be met if blood sugar can immediately enter the cells, and this is very dependent on the performance of insulin. Rising cortisol levels will reduce insulin action in the blood (21).

The protein efficiency ratio is influenced by the fish's capacity to digest food. More optimal protein absorption will result in increased availability of amino acids needed for growth. A high level of overall feed nutrient absorption will increase energy availability, which in turn will increase the efficiency of protein use. So, amino acids will be more effectively used as building materials for the body rather than as an energy source. Protein is one of the complex macromolecules in organisms that functions as a cell signal receptor, enzyme, hormone, ion channel, oxygen, CO transporter in hemoglobin, muscle building, tissue binding and growth energy.

Metabolism is a definition that describes macromolecular changes, especially in organic compounds, resulting from chemical-biological transformations. Specially acting enzymes strongly support this metabolic process. Biochemical metabolic actions consist of the formation and breakdown of organic macromolecules such as proteins, fats and carbohydrates into nucleic acids (22). Chemical and energetic changes or transformations that occur in the body are called metabolism (23).

3.5 Body Fat Rate

Fat is the main energy source in fish, the energy in feed affects the growth rate and survival of fish seeds (24). The results of research on the fat of catfish treated with bioprisma probiotics and probiotics in the biofloc aquaponic technology respectively, namely the P0 was 1.78%, the P1 was 8.73%, and the P2 was 7.34%. The results of the analysis of variance presented in that the liquid probiotic fortification of bioprisma and biogan has a significant effect on the fat of catfish where F_{count} (13,69) > F_{table} 5% (5.14), which means that the fat of catfish meat in all treatments is significantly different but the value is relatively the same. This means, H0 which stated that there was no effect of bioprism and biogan liquid probiotic fortification on the fat of catfish meat in the biofloc aquaponic technology was rejected, while H1 which stated that there was an effect of bioprisma and biogan liquid probiotic fortification on the fat of catfish meat in the biofloc aquaponic technology was accepted.

The results of the fat research that has been carried out are in accordance with the results of the proximate analysis of catfish meat carried out by (12), where the fat of catfish ranges between 1.81-6.57%. According to (13), the fat in catfish is 1.09-5.47%. According to (14) that the nutritional value of catfish in fresh form contains 1.09-5.8% fat, so it is said that the liquid probiotic fortification of bioprisma and biogan has a significant effect on the fat of catfish because, at P1 the fat produced is 8, 73%; and P2 the fat produced was 7.34%.

Testing the fat of catfish meat in the research, the highest result in P1 was 8.73%, this is because the probiotic composition of bioprisma is one of the trademarks in the form of a combined culture of several beneficial microorganisms including, the group of lactic acid bacteria, namely *Lactobacillus sp.* and *sp* (25). Utilizing these bacteria as probiotics is useful for neutralizing ammonia and preventing the

presence of pathogens in the digestive tract. Catfish is a type of medium fatty fish, according to (26), the need for fish oil is different and really depends on the stage of the fish, type of fish etc. for the environment. Too high a fat in fish can cause excess fat storage in the fish's body, resulting in kidney damage, edema and anemia leading to death. Bacterial activity *Lactobacillus sp.* and bacteria *Acetobacter sp.* which live in colonies and stick to the intestinal walls of fish, forcing pathogenic bacteria not to develop and disrupt the fish's digestive process (27).

If the energy of the feed is too high, the amount of feed consumed by the fish is reduced because their metabolic energy needs are immediately met, thereby slowing down the growth rate of the fish fry. Energy levels that are too high increase the accumulation or storage of fat, which disrupts liver function and reduces survival, while energy levels that are too low slow down the growth rate because fish use feed protein as an energy source, so that the efficiency of protein biosynthesis in the fish's body decreases. Therefore, the ratio between protein and energy in feed must be known to support fish survival and growth (28). Providing probiotics in feed is one way to increase the growth rate and survival rate of fish (27). Probiotics are live microbes that are beneficial because they create optimal conditions for feed digestion and increase the efficiency of nutrient utilization, thereby facilitating nutrient absorption and accelerating growth (29). Probiotic administration affects the speed at which food is absorbed in the digestive tract. The higher the absorption capacity of fish seeds for the nutrients in the feed, the more nutrients will be stored in the fish's body as energy reserves. The stored energy reserves are then used to increase the weight of the fish (30).

Fat is one of the components of macromolecules that are necessary for living creatures to live as a source of high energy and a solvent for vitamins. Fat also works in the body to form the body's cell walls. If fat consumption is excessive, the fat in the body increases and causes several diseases related to increased fat (31). The breakdown of fat in adipocytes requires the catalytic activity of triacylglycerol lipase, diglyceride lipase and monoglyceride lipase. The breakdown process begins with the breakdown of fatty acids and glycerol into acetyl-CoA and entering the Krebs cycle to be converted into phosphoglyceraldehyde. The following is a fat metabolism presented in Figure 1.

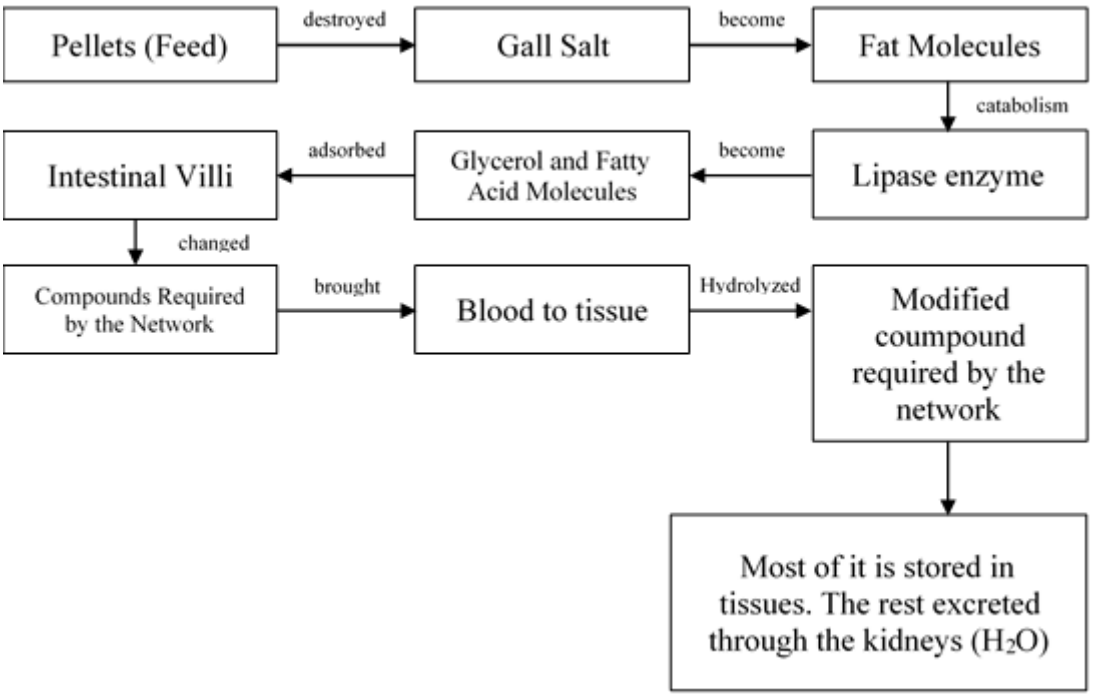

Figure 1. Fat metabolism in fish

3.6 Biofloc Aquaponics System Water Quality

Water samples tested for Ammonia, Nitrite, Nitrate and DO are presented in table 9. Several physical factors of water quality play an important role in survival and productivity in the metabolic processes that occur in the fish body. Physical factors that are water quality parameters in freshwater fish cultivation include: temperature, pH, DO, ammonia and nitrate (32). Based on Table 9, the ammonia test results are below standard standards. According to (25), bioprisma probiotics contain *Lactobacillus sp.* and *Acetobacter sp*. Bacteria *Acetobacter sp.* plays a role in preventing the growth of pathogenic bacteria in the intestine (27). Bacteria *Lactobacillus sp*. are bacteria that are very useful in food digestion, increasing nutritional efficiency in feed and reducing odor in feces or metabolic waste. According to (33) that biogan probiotics contain 0.32% nitrogen, 0.03% P_2O_6, 0.92% potassium, 2.17% sulfur, SO_4 0.04%, Fe 0.01%, CuO 0.26%, and Mg 0.02%. This organic material can be used directly by phytoplanktons in the water for their survival. Phytoplankton are food for zooplankton, so they are abundant. This causes the waters to become fertile.

In general, nitrite is a problem in fish farming systems, because excessive levels of nitrite in ponds contribute to decreased water quality, affecting fish growth and survival (34). The results of the nitrite P0 test were 0.002 mg/L, P1 was 0.007 mg/L and P2 was 0.006 mg/L. It can be concluded that the nitrite is slightly less than the standard standard <1 mg/L. According to (35), *Lactobacillus sp.* contains extracellular enzymes that can help digestion and can improve water quality through decomposition and regeneration of organic matter in the water, so that high nitrite in the water does not endanger the survival of fish.

The nitrate of waters is used as a reference for water fertility, because the more phytoplankton in a body of water determines the high primary productivity of that water (36). The results of the nitrate test P0 were 6 mg/L, P1 was 7.2 mg/L, P2 was 7.2 mg/L. It can be concluded that the nitrate is lower than the standard of 20 mg/L. (37) stated that the concentration of NO_3-N in biofloc technology is better not to exceed 10.0 mg/L. DO level is the amount of oxygen in the water derived from the process of photosynthesis and air diffusion. Dissolved oxygen in water is used for the respiration process, breaking down organic and inorganic materials, metabolic processes which then produce energy for growth and reproduction. The aquaponic biofloc technology system has stable DO levels when compared to the conversional system. This can be seen in table 9 where the DO in treatment P0 is 7.5 mg/L, P1 is 8.55 mg/L, P2 is 8.25 mg/L, it can be concluded that the DO is greater than the standard standard $\geq$ 3 mg/L.

According to (38) the presence of fish, plants and bacteria are very important elements in fish cultivation, because the presence of these three elements creates a mutualistic symbiosis, namely a mutually beneficial relationship. Fish produce N or P elements from feces and food waste, namely bacteria that convert uneaten food and fish waste into active nitrate as a source of nutrition for plants, while plants provide water free of toxic gases from metabolic waste that fish need during the rearing process, using nitrogen (NH_3-N, NO_2-N give NO_3-N) and CO_2 produced during fish farming..

Biofloc technology is created thanks to a consortium of microorganisms in the aquaponic technology. The nitrogen cycle and nitrification processes cannot be separated in an aquaponic technology. In aquaponic technology there is organic and inorganic nitrogen. Organic nitrogen is nitrogen in the form of protein, amino acids and urea. Meanwhile, inorganic nitrogen can be in the form of NH_3, NH_4, NO_2, NO_3 and N_2. Through the breakdown of amino acids by various aerobic and anaerobic bacteria, organic material from food waste and fish waste is broken down and forms NH_3. If the NH_3 in water increases, then the O_2 in water is reduced. Bacteria nitrosomonas slowly takes over the process of breaking down organic materials into nitrite compounds. Nitrobacter bacteria convert nitrite into nitrate and the nitrite salt is then purified into nitrate salt. Nitrite salt is a compound that can be consumed by green plants to rearrange the amino acids in their bodies and form protoplasm, which then depends on nitrite. These nitrites are broken down into free nitrogen by denitrifying bacteria, Micrococcus denitrifying (39).

4. Conclusion

Based on the results of the study, it can be concluded that the protein metabolism of catfish given bioprism and biogan probiotics obtained significantly different results F_{count} (165.51) > F_{table} 5% (5.14), where the highest protein was obtained in P1 treatment of 18.70% while body fat of catfish obtained real different results F_{count} (13.69) > F_{table} 5% (5.14), where the highest fat in the treatment. Nutritional requirement studies, especially regarding protein and fat towars maintenance and growth, can help in efficiently managing protein and fat requirement and feed utilization capacity among catfish. Studies with biofloc aquaponics technology with probiotics can expand ecological bacterial functions using these biotechnologies in aquaculture.

Acknowledgements

The authors appreciate Universitas Persatuan Guru Republik Indonesia Semarang (UPGRIS) for support in this article

References

[1] Anjar R, Yustiati A, Andriani Y. Teknik Pembenihan Ikan Patin (Pangasius Hypopthalmus) Sistem Corong Fishing Engineering Catfish (Pangasius hypopthalmus) Funnel System. Jurnal Akuatek. 2022;3(1):33–40.

[2] Hai NV. The use of probiotics in aquaculture. J Appl Microbiol. 2015 Oct;119(4):917–35.

[3] Singh S, Negi T, Sagar NA, Kumar Y, Tarafdar A, Sirohi R, et al. Sustainable processes for treatment and management of seafood solid waste. Science of The Total Environment. 2022 Apr;817:152951.

[4] Pinho SM, de Lima JP, David LH, Emerenciano MGC, Goddek S, Verdegem MCJ, et al. FLOCponics: The integration of biofloc technology with plant production. Rev Aquac. 2022 Mar 29;14(2):647–75.

[5] Abakari G, Wu X, He X, Fan L, Luo G. Bacteria in biofloc technology aquaculture systems: roles and mediating factors. Rev Aquac. 2022 Jun 18;14(3):1260–84.

[6] Robles-Porchas GR, Gollas-Galván T, Martínez-Porchas M, Martínez-Cordova LR, Miranda-Baeza A, Vargas-Albores F. The nitrification process for nitrogen removal in biofloc system aquaculture. Rev Aquac. 2020 Nov 20;12(4):2228–49.

[7] Monroy Dosta C, Alejandro Rodriguez G, Castro Mejía J, Becerril D, del Carmen Monroy Dosta M, Rodríguez Montes de Oca A, et al. Importance and function of microbial communities in aquaculture systems with no water exchange. Scientific Journal of Animal Science. 2015;4(9):103–10. Available from: www.Sjournals.com

[8] Crab R, Defoirdt T, Bossier P, Verstraete W. Biofloc technology in aquaculture: Beneficial effects and future challenges. Aquaculture. 2012 Aug;356–357:351–6.

[9] Sulistya Dewi ER, Nugroho AS, Ulfah M. Water Quality in the Maintenance of Oreochromis niloticus through Environmentally Friendly Biofloc Technology. IOP Conf Ser Mater Sci Eng. 2020 Apr 1;835(1):012008.

[10] Dewi ERS, Nugroho AS, Ulfah M. Development of combination of environmentally friendly biofloc and aquaponic systems in the maintenance of Oreochromis Niloticus. Innovative Science And Research Technology. 2020;5(5):2456–2165.

[11] Betlehemia B. enetapan Kadar Protein dan Lemak dari Berbagai Jenis Ikan Lele di Kecamatan Pancur Batu dengan Metode Kjeldahl dan Sokletasi. [Medan]: Universitas Sumatera Utara; 2016.

[12] Suryaningrum TD, Ikasari D, Supriyadi S, Mulya I, Purnomo AH. Karakteristik Kerupuk Panggang Ikan Lele (Clarias gariepinus) dari Beberapa Perbandingan Daging Ikan dan Tepung Tapioka. Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan. 2016 Jun 1;11(1).

[13] Hashim RB, Jamil EF, Zulkipli FH, Daud JM. Fatty Acid Compositions of Silver Catfish, <i>Pangasius</i> sp. Farmed in Several Rivers of Pahang, Malaysia. J Oleo Sci. 2015;64(2):205–9.

[14] Orban E, Nevigato T, Lena G Di, Masci M, Casini I, Gambelli L, et al. New trends in the seafood market. Sutchi catfish (Pangasius hypophthalmus) fillets from Vietnam: Nutritional quality and safety aspects. Food Chem. 2008 Sep;110(2):383–9.
[15] Arfiati D, Lailiyah S, Pratiwi RK, Alvateha D, Aisyah FDD, Dina KF. Efforts to Reduce Organic Matter In Shrimp Aquaculture Wastewater With Various Bacterial Consortium Trademarks. Journal of Aquaculture Science. 2021 Jul 31;6(1IS):97–109.
[16] Aoudia N, Rieu A, Briandet R, Deschamps J, Chluba J, Jego G, et al. Biofilms of Lactobacillus plantarum and Lactobacillus fermentum: Effect on stress responses, antagonistic effects on pathogen growth and immunomodulatory properties. Food Microbiol. 2016 Feb;53:51–9.
[17] Sakana. Efektivitas Probiotik dengan Carrier Zeolit pada Media Pemeliharaan Udang Galah (Macrobrachium rosenbergii). Jurnal perikanan dan Ilmu kelautan. 2013;4(3):57–66.
[18] Tahapari E, Darmawan J. Kebutuhan Protein Pakan Untuk Performa Optimal Benih Ikan Patin Pasupati (Pangasiid). Jurnal Riset Akuakultur. 2018 Mar 1;13(1):47.
[19] Putra Wangni G, Prayogo S, Sumantriyadi S. Kelangsungan hidup dan pertumbuhan benih ikan patin Siam (pangasius hypophthalmus) pada suhu media Pemeliharaan yang berbeda. Jurnal Ilmu-ilmu Perikanan dan Budidaya Perairan. 2019 Dec 3;14(2).
[20] Saefudin Yuli, H. Harris, Indah Anggraini Yusanti. Tingkat Serangan Ektoparasit pada Ikan Patin (Pangasius Hypopthalmus) yang Dibudidayakan dalam Keramba Jaring Apung di Sungai Musi Palembang. Jurnal Perikanan Dan Kelautan. 2014;1(1).
[21] Tang UM, Aryani N, Masjudi H, Hidayat K. Pengaruh Suhu Terhadap Stres Pada Ikan Baung (Hemibagrus Nemurus) (Effect of Temperature on Stress on Malay Catfish (Hemibagrus Nemurus). Asian Journal of Environment. 2018;2(1):43–9.
[22] Wali JA, Ni D, Raubenheimer D, Simpson SJ. Macronutrient interactions and models of obesity: Insights from nutritional geometry. BioEssays. 2024 Nov 6;
[23] Putra AN. Metabolisme Basal Pada Ikan (Basal Metabolism in Fish). Jurnal Perikanan dan Kelautan. 2015;5(2):57–65.
[24] Suhenda N, Setijaningsih L, Suryanti Y. Penentuan rasio antara kadar karbohidrat dan lemak pada pakan benih ikan patin jambal (Pangasius djambal). Jurnal Penelitian Perikanan Indonesia. 2017 Mar 9;9(1):21.
[25] Menurunkan Kadar BOD Air Limbah Domestik Cahyono Ikhsan U, Utomo B, Qomariyah S, Hari Wahyudi A, Yulianto B, Soeryodarundio K. Probiotik Multitalenta Pseudomonas Fluorescens (PMPF). AMMA : Jurnal Pengabdian Masyarakat. 2022;1(11).
[26] Isa M, Zalia Btb T, Harris A, Herrialfian dan. Proximate Analysis of Fat Content on Tilapia Fish Suplemented with Willow Leaf Combinated with Chromium in Feed after Exposured of Heat Stress. Jurnal Medika Veterinaria. 2015;9(1).
[27] Ahmadi H, Nia Kurniawati dan, Fakultas Perikanan dan Ilmu Kelautan Unpad A, Dosen Fakultas Perikanan dan Ilmu Kelautan Unpad S. Pengaruh Pemberian Probiotik dalam Pakan Terhadap Pertumbuhan Benih Ikan Bawal Air Tawar (Colossoma macropomum). Jurnal Perikanan dan Kelautan. 2012;3(4):99–107.
[28] Bharvi S. Patel, Bhanu R. Solanki, Archana U. Mankad. Effect of eco-enzymes prepared from selected organic waste on domestic waste water treatment. World Journal of Advanced Research and Reviews. 2021 Apr 30;10(1):323–33.
[29] Afdola. Pengaruh Pemberian Probiotik dalam Pakan Terhadap Pertumbuhan Benih Ikan Bawal Air Tawar (Colossoma macropomum). Jurnal Fakultas Perikanan dan Kelautan. 2018;3–8.
[30] Syaifariz A. Budikdamber Sebagai stategi penguatan ketahanan pangan dan perekonomian masyarakat kabupaten Brebes di tengah pandemi. Jurnal Abdidas [Internet]. 2020;2:41–7. Available from: http://jurnal.umj.ac.id/index.php/semnaskat
[31] Jufri NN, Wirjatmadi B, Adriani M. Combined Food (Bekatul dan Lemak) Menurunkan Kadar Kolesterol Total, Trigliserida, dan LDL pada Tikus Galur Wistar. Jurnal Kedokteran Brawijaya. 2015 Feb 13;28(3):208–12.

[32] Marlina E., Rakhmawati. Kajian Kandungan Amonia Pada Budidaya Ikan Nila (Oreochromis niloticus) Menggunakan Teknologi Akuaponik Tanaman Tomat (Solanum lycopersicum). In: Prosiding Seminar Nasional Tahunan Ke-V Hasil-Hasil Penelitian Perikanan dan Kelautan. 2016. p. 181–7.
[33] Narayana Y. Pengaruh Penambahan Probiotik pada Pakan dengan Dosis yang Berbeda Terhadap Pertumbuhan Ikan Nila (Oreochromis sp.). Jurnal Agrokompleks. 2019;6(1):1–5.
[34] Malwa F, Anggoro A, Johan Y. Pengujian Kualitas Air Pada Pembenihan Bawal Bintang. 2022. 226–230 p.
[35] Adi Kusuma M, Tang UM, Perikanan dan Kelautan F, Riau U. Jurnal Ilmu Perairan (Aquatic Science) Pengaruh Pemberian Probiotik dengan Dosis Berbeda pada Media Pemeliharaan Terhadap Pertumbuhan Ikan Patin (Pangasianodon hypophthalmus) dengan Sistem Resirkulasi Akuaponik. Ilmu Perairan (Aquatic Science). 2021;
[36] Mustofa A. Kandungan Nitrat dan Pospat Sebagai Faktor Tingkat Kesuburan Perairan Pantai. Jurnal DIPOSTEK. 2015;6(1).
[37] Ombong F, Salindeho IRN. Aplikasi teknologi bioflok (BFT) pada kultur ikan nila, Orechromis niloticus) (Application of biofloc technology (BFT) in the culture of Nile tilapia, Oreochromis niloticus). Vol. 4, Budidaya Perairan Mei. 2016.
[38] Shobihah HN, Yustiati A, Andriani Y. Produktivitas Budidaya Ikan dalam Berbagai Konstruksi Sistem Akuaponik (Review). Akuatika Indonesia. 2022 Mar 29;7(1):34.
[39] Nugroho RA, Pambudi LT, Chilmawati D, Herjuno A, Haditomo C, Program SP, et al. Apilkasi Teknologi Akuaponik pada Budidaya Ikan Air Tawar untuk Optimalisasi Kapasitas Produksi. Vol. 8, Jurnal Saintek Perikanan. 2012.