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Application Biofloqua Technology as a Solution to Increase the Survival of Snakehead Fish (*Chana striata*) in the Cirebon Region

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Abstract. The application of biofloc-aquaponics (biofloqua) in snakehead fish (*Chana striata*) cultivation is the right solution to increase production and meet high market demand in the Cirebon area. The method used in the preparation of this article is a literature study from various national and international reputable journals. The application of biofloc-aquaponics technology (biofloqua) can be done by making circular planting ponds accompanied by ropes and wires attached to the top of the pond to bind the charcoal and water spinach, winds are made in each pond with 5 additional points of molasses and probiotic swamps as starters. Snakehead fish (*Chana striata*) was stocked and adjusted, then given three times a day commercial feeding and protein diet. The kale seeds were sown on rockwool substrate in a damp room without sunlight and after roots and a few leaves appeared on the rockwool substrate, they were planted in aquaponic containers. The application of technology Biofloc-aquaponics (biofloqua) can improve the life recovery of snakehead fish (*Chana striata*). The integration of biofloqua technology can be used as a simple cultivation system in producing fish and vegetables.

Keywords: Biofloc Technology; Snakehead Fish (*Channa striata*); Cirebon Region

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INTRODUCTION

The geographical condition of Cirebon City is a lowland area with coastal characteristics. Based on Indonesian Law No. 27 of 2007, coastal areas are defined as transitional zones between marine and terrestrial ecosystems that are influenced by changes from both the sea and the land. Coastal areas have great potential to be developed to improve the economy, particularly in fisheries and marine sectors, which can become leading commodities. In fisheries, the potential catch of marine fish in the coastal area of Cirebon City reaches a total of 7,014,000 tons per year, according to the West Java Provincial Fisheries Office (Kumala et al., 2018).

According to the findings reported by Zulfikri et al. (2023), the leading capture fisheries commodity in Cirebon City is squid (*Loligo sp*). In addition, several species are identified as potential capture fisheries commodities, including scad (Decapterus pusailus), mullet (*Mugil cephalus*), cutlassfish (*Trichlurus lepturus*), grouper (*Epinephelus sp*), short mackerel (*Rastrelliger kanagurta*), tuna-like fish (*Euthynnus affinis*), blue swimming crab (*Portunus pelagicus*), dogol shrimp (*Metapenaeus monoceros*) and Snakehead fish (*Channa striata*) is categorized as a non leading commodity.

The snakehead fish (*Channa striata*) is a freshwater species with high economic value whose population continues to decline. The species has significant potential, particularly due to its medicinal benefits. Research has shown that snakehead fish contains albumin, which has many sulfhydryl (-SH) groups that function as radical-binding agents. Proteins rich in -SH groups can bind harmful metals and compounds with antioxidant effects, as well as sialic acid. In nature, most snakehead fish caught measure less than 30 cm, and individuals reaching 50 cm have become rare (Adipu & Rovik, 2018).

The numerous benefits of snakehead fish have led to high demand among the public. One method to increase snakehead fish production is through aquaculture technology. The application of biofloc-aquaponics technology in snakehead fish farming is an appropriate solution to increase production and meet high market demand (Wijayanti et al., 2023). Biofloc is a technology that manages water quality and provides additional feed for cultivated fish (Mulyadi et al., 2016). Biofloc utilizes the activity of heterotrophic and autotrophic microorganisms to convert organic waste into floc, which can be used as fish feed. Floc consists of bacteria, plankton, fungi, algae, and suspended particles that influence the structure and nutrition of biofloc. Biofloc uses constant aeration for aerobic decomposition and to keep particles suspended. Heterotrophic bacteria in biofloc act as bioreactors that control water quality and serve as a protein source. The formation of biofloc aims to improve nutrient utilization, reduce environmental stress, and prevent predation (Dewi, 2022).

Combining biofloc systems with aquaponics can reduce water exchange in aquaculture, making it more environmentally friendly. Water from the biofloc tank is channeled into a hydroponic system, with an added filter basket containing serrated rubber balls and zeolite stones as water filters. The function of these filters is to increase oxygen levels, neutralize pH, promote plankton growth, absorb pollutants from waste and leftover feed, and maintain pond water quality (Dewi, 2022). The application of biofloc-aquaponics technology has shown positive results in other fish species, such as catfish. According to research conducted by Wijayanti et al. (2021), catfish cultured under the Biofloqua (biofloc-aquaponics) system demonstrated improved growth and survival rates of up to 96% with an FCR of <1.00. The combination of biofloc and aquaponics with the addition of swamp bacteria helps maintain water quality in aquaculture to optimize stocking density and distribution. Using biofloc and Nitrobacter supports the highest specific growth rate and the lowest FCR (Puspita, 2018), as observed in laboratory-scale snakehead fish biofloc research using probiotic swamp starters (Wijayanti et al., 2020).

The combination of biofloc and aquaponics provides benefits that support sustainable aquaculture, as it is both profitable and environmentally friendly (Wijayanti et al., 2023). The purpose of this study is to analyze the application of biofloc-aquaponics (Biofloqua) to increase the survival rate of snakehead fish (*Channa striata*) in the Cirebon region. This research is expected to provide valuable information to the public, especially in the Cirebon area, to encourage the utilization of biotechnology in fisheries, particularly biofloc-aquaponics (Biofloqua), to improve the survival and productivity of snakehead fish (*Channa striata*).

MATERIALS AND METHODS

This study employed data collection and selection methods based on reputable national and international journal articles related to biofloc-aquaponics (Biofloqua), using literature or library research. The literature search was conducted using the following keywords: biofloc-aquaponics, snakehead fish (*Channa striata*), and Cirebon region. The data obtained were secondary data derived from various previous research findings, allowing logical conclusions to be drawn from existing studies. These data were used to describe the geographical characteristics of the Cirebon region, outline the procedures for developing a biofloc-aquaponics (Biofloqua) system, and analyze the system's potential to improve the survival rate of snakehead fish (*Channa striata*) using the research design adopted from (Wijayanti et al., 2023).

Research Design

This study employed a Completely Randomized Design (CRD) consisting of two treatments and three replications. The treatments were as follows:

P1 = Rearing 100 ind·m^{-3} using the biofloc-aquaponics (Biofloqua) system
P2 = Rearing 100 ind·m^{-3} using the biofloc system
(Wijayanti et al., 2023).

Research Parameters

The parameters observed in this study included survival rate, total weight gain, total length gain, feed efficiency, kangkong (*Ipomoea aquatica*) length growth, floc volume, and water quality parameters during snakehead fish (*Channa striata*) culture, namely pH, TDS, BOD, and DO (Wijayanti et al., 2023).

Survival Rate Calculation

Fish survival rate was calculated using the following formula:

$$SR: \frac{Nt}{No} x\ 100\%$$

Nt = Number of fish that survived at the end of the rearing period (individuals)
No = Number of fish at the beginning of the rearing period (individuals)
(Rismoni et al., 2022)

Absolute Length Growth

Absolute length growth was calculated using the formula:
L = Lt – Lo
Lt = Fish length at the end of the study (cm)
Lo = Fish length at the beginning of the study (cm)
(Rismoni et al., 2022)

Absolute Weight Growth

Absolute weight gain was calculated based on the following formula:
W = Wt – Wo
Wt = Fish weight at the end of the study (g)
Wo = Fish weight at the beginning of the study (g)
(Rismoni et al., 2022)

Floc Volume Measurement

Floc volume was measured once a week using an Imhoff cone. A 1000-ml water sample was placed into the cone and allowed to settle for 15 minutes. The floc sediment accumulating at the bottom was then read from the scale on the Imhoff cone (Rismoni et al., 2022)

Water Quality

Water quality parameters measured weekly included pH, TDS, BOD, and DO (Rismoni et al., 2022).

Data Analysis

Data on the geographical characteristics of the Cirebon region and the procedures for constructing the biofloc-aquaponics (Biofloqua) system were analyzed descriptively. Meanwhile, data on water quality, floc volume, survival rate, growth, and feed efficiency were analyzed using the t-test (Wijayanti et al., 2023).

RESULTS AND DISCUSSION

Research Location

The research location carried out in this study was in the Cirebon Coastal Area, which can be seen in Figure 1.

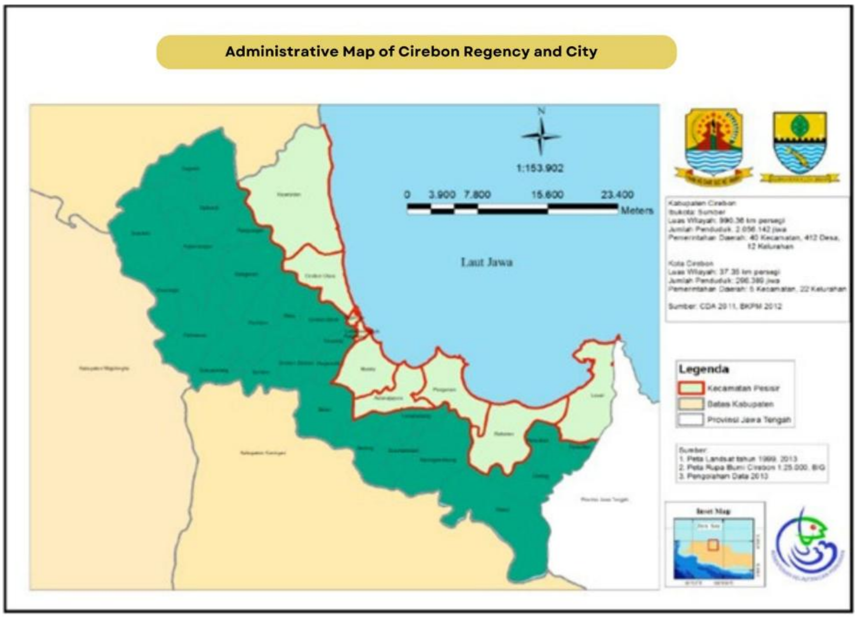

Figure 1. Coastal Area of Cirebon

Based on its geographical position, the Cirebon region is located between 108°40’–108°48’ East Longitude and 6°30’–7°00’ South Latitude, and is bordered by:

a. The north: Indramayu Regency
b. The northwest: Majalengka Regency
c. The south: Kuningan Regency
d. The east: Cirebon Municipality and Brebes Regency (Central Java)

Subdistricts located along the northern coastal route (Pantura) lie within lowland areas with elevations ranging from 0–10 meters above sea level, while subdistricts located in the southern part of the region have elevations ranging from 11-130 meters above sea level. The total administrative area covers 990.362 km² (Rizal et al., 2017).

The assembly and operation of the Biofloc-Aquaponics System can be seen in Figure 2.

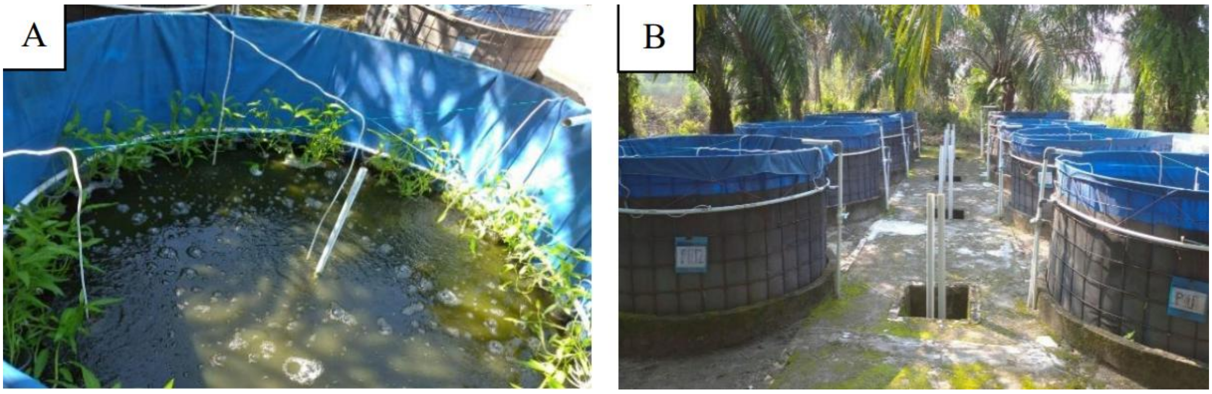

Figure 2. Assembly and Operation of the Biofloc–Aquaponics System.
Biofloqua Pond (Biofloc-Aquaponics) as Treatment 1 (A) and Biofloc Pond for Snakehead Fish Rearing as Treatment 2 (B)

The rearing ponds used were circular tarpaulin tanks with a diameter of 2 m, a height of 1 m, and a water depth of 0.5 m. Ropes and wires were attached to the upper part of the pond to secure charcoal and water spinach (*Ipomoea aquatica*) (Figure 2A). The wires functioned as reinforcement to keep the structure stable against rain and wind. Each pond was equipped with aeration at five points. Molasses and swamp probiotics were added as starters at 10 mL m^{-3} with a bacterial density of 10^5 CFU mL^{-1}. Snakehead fish were stocked and acclimated for 10 days. The probiotics used were derived from swamp environments, consisting of *Bacillus sp.* and *Streptomyces sp.*, selected from swamp sediments. *Bacillus sp.* and *Streptomyces sp.* functioned as probiotic bacteria in the culture system, enhancing feed efficiency, survival rate, and growth of snakehead fish while maintaining water quality. The fish were fed commercial feed containing 40% protein, provided three times daily. The snakehead fish were reared for 42 days after treatment, and the weight and length of the fish were measured weekly. Molasses was added weekly at 100 mL m^{-3}. Water spinach seeds were sown on rockwool substrates in a humid, shaded room for 14 days. After roots and several leaves developed on the rockwool substrate, the seedlings were transferred to the aquaponics unit. The aquaponics medium was installed three days after the fish were stocked in the rearing ponds. Water spinach plants were harvested after 21 days (Wijayanti et al., 2023).

Biofloc-Aquaponics System to Improve the Survival of Snakehead Fish (*Chana striata*)

The aquaponics system is a combined method integrating aquaculture and hydroponic techniques. Aquaculture in aquaponics commonly applies the biofloc method, allowing microorganisms to process feed residues and excretory products into flocs (biofloc). The function of biofloc is to improve water quality by converting nitrogenous waste into flocculates, which serve as an additional feed source for cultured fish in the aquaponics system. The application of a biofloc-aquaponics system reduces water exchange in aquaculture activities, making it more environmentally friendly. It also reduces the amount of feed required (Dewi, 2022).

The benefits and advantages of the biofloc-aquaponics system include reduced feed usage, uniform fish growth, healthier fish conditions, and decreased pathogen infection. Additionally, the system helps save cultivation space, provides a more appealing pond appearance particularly when using circular tanks and improves efficiency in feed, water, and layout management. The biofloc-aquaponics system reduces the need for water replacement due to the presence of a natural water purification cycle that processes feed waste and toxic gases. Reduced water exchange lowers the risk of pathogen entry from outside the system. The biofloc-aquaponics system is more stable because biofloc consists not of a single bacterium but of a community of floc-forming bacteria working synergistically (Dewi, 2022).

The pH of pond P1 (Biofloqua) ranged from 6.1 to 7.7, while the pH of pond P2 (Biofloc) ranged from 6.0 to 7.7. These values indicate that the pH in both rearing media remained within the tolerance range for the maintenance, survival, and growth of snakehead fish. Snakehead fish, commonly found in swamp ecosystems, typically inhabit acidic to neutral waters with pH ranging from 4 to 7. The Biofloc and Biofloqua cultivation systems, which utilize bacterial and microbial activity in the formation of flocs, have been shown to maintain water pH within the tolerance limits of snakehead aquaculture. Bacterial activity in decomposing organic matter can produce organic acids, resulting in lower pH values. Conversely, increased pH may occur due to reduced bacterial activity, leading to lower organic acid production and consequently higher pH in the rearing media (Wijayanti et al., 2023).

At high pH levels, ammonia concentration increases, reducing the ability of fish to excrete ammonia. This results in elevated ammonia levels in the blood and tissues. Increased ammonia in the blood also raises blood pH, negatively affecting various enzymatic reactions and membrane stability. These adverse effects include gill damage, reduced blood oxygen carrying capacity, and histological damage to red blood cells (Dewi 2022).

The dissolved oxygen (DO) levels in the rearing media ranged from 4.45±0.10 to 5.95±0.36 mg L^{-1}. In treatment P1 (Biofloqua), DO ranged from 4.45±0.10 to 5.90±0.12 mg L^{-1}, while in treatment P2 (Biofloc), it ranged from 5.25±0 to 5.95±0.17 mg L^{-1}. The differences in DO levels are believed to result from variations in photosynthesis and respiration by fish and microorganisms, which differ between Biofloqua and Biofloc systems. Freshwater fish generally tolerate dissolved oxygen levels above 3-5 mg L^{-1}. DO is required not only by fish but also by aquatic microbes involved in floc formation. It also plays a crucial role in the cultivation of Biofloqua and Biofloc bacterial communities, aiding in the decomposition of organic matter by probiotic bacteria, thereby reducing organic load in the system (Wijayanti et al., 2023).

Dissolved oxygen in aquaculture systems must remain within the optimal range, as suboptimal DO levels can cause stress in fish. When oxygen concentrations are sufficiently high, the fry disperse evenly. Conversely, when oxygen levels are low, the fry concentrate in areas with strong aeration or near water inlets (Amin et al., 2023).

The Total Dissolved Solids (TDS) levels in the rearing media ranged from 284.50±163.25 to 488.17±420.59 mg L^{-1}. In treatment P1 (Biofloqua), TDS ranged from 416±233.50 to 488.17±420.59 mg L^{-1}, while in treatment P2 (Biofloc), it ranged from 284.50±163.25 to 328.67±301.31 mg L^{-1}. The variations in TDS between systems are believed to be due to differences in nutrient content, particularly nitrogen originating from fish waste. Plants require nitrogen as a natural fertilizer for their growth and development (Wijayanti et al., 2023). Table 1 presents the results of the t-test analysis of TDS values in the snakehead fish rearing media.

Table 1. TDS value in snakehead fish maintenance media for 42 days (mg L^{-1})

Day to day maintenance	Treatment	
	P1 (Biofloqua)	P2 (Biofloc)
0	386.25+73.25	231.50±9.00
7	377.50±86.50	241.75±5.75
14	474.50±58.00	223.25±7.75
21	366.75±53.75	234.00±3.75
28	383.75±60.25	244.50±13.00
35	479.75±60.75	242.25±10.75
42	389.00±33.50	237.50±6.00

The results of the t-test analysis (Table 1) show that total dissolved solids (TDS) did not differ significantly between treatments P1 and P2 on days 0, 7, 14, 21, 28, 35, and 42 ($P<0.05$). Based on water quality standards in Government Regulation (PP) No. 82 of 2001 (Class II), TDS concentrations below 1000 mg L^{-1} such as those recorded throughout the rearing period are considered suitable and safe for aquaculture activities (Wijayanti et al., 2023). The lower the TDS concentration in the water, the better it is for fish cultivation. Changes in TDS levels may pose risks because water density influences the movement of water into and out of an organism's cells. High TDS concentrations can reduce water clarity and consequently decrease photosynthetic activity.

The TDS values reported by Wijayanti et al. (2023) were higher than those recorded by (Dewi et al. 2022) who obtained TDS values ranging from 160.6 to 160.87 mg L^{-1}. This difference is presumed to be due to the aquaponics system used in the study by (Dewi et al. 2022), in which plants effectively helped reduce dissolved nutrients in the water of the fish seed culture system.

The BOD range observed in the rearing media was between 0.48 ± 0.12 and 0.68 ± 40.25 mg L^{-1}. Treatment P1 (biofloqua) ranged from 0.48 ± 0.12 to 0.68 ± 40.25 mg L^{-1}, while treatment P2 (biofloc) ranged from 0.50 ± 0 to 0.68 ± 0.23 mg L^{-1} (Wijayanti et al., 2023). The results of the t-test analysis for BOD values in the snakehead rearing media are presented in Table 2.

Table 2. BOD values in the snakehead fish rearing media over 42 days (mg·L^{-1})

Treatment	Day to day maintenance						
	0	7	14	21	28	35	42
P1	0.63±0.38	0.53±0.15	0.55±0.17	0.48±0.12	0.68±0.25	0.68±0.21	0.48±0.15
P2	0.67±0.15	0.50±0.0	0.62±0.12	0.62±0.15	0.65±0.20	0.55±0.20	0.68±0.23

The results of the t-test analysis (Table 2) showed that the Biochemical Oxygen Demand (BOD) on days 0, 7, 14, 21, 28, 35, and 42 did not differ significantly between treatments P1 and P2 ($P < 0.05$). The BOD values during the rearing period ranged from 0.48±0.12 mg L^{-1} to 0.68±0.25 mg L^{-1}. BOD values can be influenced by temperature, plankton density, the presence of microbes, and the type of organic material (Wijayanti et al., 2023). BOD levels in natural waters generally range from 0.5-7.0 mg L^{-1}. The low BOD values in this study were due to the fact that microbes in the probiotics and the plants were able to utilize organic matter as a nutrient source.

A combination of Streptomyces sp. and Bacillus sp. (Bernal et al., 2016) has a synergistic effect, in which the bacteria benefit one another by producing various extracellular enzymes (*Bacillus sp.*) and antibiotic compounds (*Streptomyces sp.*) that can enhance fish survival, growth, and disease resistance. *Bacillus sp*. naturally produces antimicrobial compounds that can suppress pathogenic bacterial colonies (Santos et al., 2021).

Streptomyces sp. has the potential to control pathogenic bacteria through competition, parasitism, or the production of secondary metabolites and can produce various biologically active compounds such as antibacterial, antifungal, antiparasitic, and antiviral agents (Al-Ansari et al., 2019). The results of the t-test analysis also showed that the floc volume in treatments P1 and P2 differed significantly on days 14, 28, 35, and 42 ($P<0.05$), as shown in Table 3.

Table 3. Floc volume in the snakehead fish rearing media over 42 days.

Day to day maintenance	Volume flok ($ml.L^{-1}$)	
	P1	P2
0	0.13 + 0.06	0.05 + 0.05
7	0.40 + 0.00	1.10 + 0.50
14	0.87 + 0.15	16.00 + 2.00
21	2.37 + 0.65	21.50 + 1.50
28	4.77 + 0.25	28.00 + 3.00
35	3.00 + 0.50	19.00 + 5.00
42	6.00 + 0.50	23.00 + 5.00

The results of the analysis in Table 3 show that the floc volume formed in Treatment P2 was higher than in Treatment P1. The low floc volume observed in Treatment P1 with the aquaponic system is presumed to be due to the utilization of nitrogen compounds by bacteria and water spinach plants. The higher floc volume in Treatment P2 (biofloc system) indicates that bacteria in the culture ponds formed flocs that could be used as fish feed. The addition of molasses as a carbon source also influenced the formation of more biofloc. This is likely because molasses is a simple sugar that can be easily utilized by heterotrophic bacteria as a carbon nutrient source (Rismoni et al., 2022). The more culture waste present in the media that is utilized by heterotrophic bacteria, the more floc is formed.

The formed flocs can provide nutrients such as proteins, amino acids, lipids, and fatty acids in various microbial forms. Biofloc is also a good source of vitamins and minerals, particularly phosphorus and microbial protein, which serve as supplemental nutrients for fish and plants (Wijayanti et al., 2023).

The results of the t-test analysis showed that the survival rate of snakehead fish did not differ significantly between Treatments P2 and P1 ($P < 0.05$). Rearing with biofloc technology and aquaponics produced a survival rate (SR) of 100 ± 0.00%, while snakehead reared with biofloc technology alone showed an SR of 99.78 ± 0.38%. This indicates that Biofloqua and biofloc treatment can maintain water quality in optimal conditions. The use of probiotics in aquaculture can help maintain microbial population balance and control pathogens in the digestive tract (Diwan et al., 2024), water, and the aquatic environment through biodegradation processes (Hlordzi et al., 2020). Table 4 presents the t-test results for feed efficiency and growth performance of snakehead fish.

Table 4. Feed Efficiency and Fish Growth Performance During 42 Days

Treatment	Feed efficiency (%)	Total Weight Growth (g)	Total Length Growth (cm)
P1	179 ± 31.66	7.39 ± 1.51	2.61 ± 0.42
P2	147 ± 36.10	6.10 ± 1.44	2.27 ± 0.27

The results showed that the feed efficiency in P1 (179%) was not significantly different compared to P2 (147%) (Table 4). Bacteria enter the digestive tract through respiration while feeding. Snakehead fish (*Channa striata*) are able to optimally utilize the flocculated environment. Thus, the bacteria in both P1 and P2 can act in the digestive tract and improve digestibility. Although the average feed efficiency in P1 and P2 was not significantly different, the Biofloqua system demonstrated better performance than the Biofloc system. Fish will have higher nutritional value if amino acid and protein levels are similar. When these values are balanced, the fish's body can digest feed optimally (Amin et al., 2023). High digestibility can enhance nutrient absorption; therefore, when the nutritional needs of the fish are met, the fish will grow well and feed efficiency will increase (Hodar et al., 2020).

The growth of water spinach (Ipomoea aquatica) was vigorous during the early cultivation period, with initial plant height ranging from 7-8 cm. Seven days after planting in the Biofloqua medium, the plant height reached 15-19 cm. After 21 days, plant height increased to 35.60-46.73 cm. The development of water spinach in the aquaponic system can be influenced by the availability of sufficient nutrients in the form of nitrate and phosphate, which are absorbed by plants in aquaponic systems (Wijayanti et al., 2023). The rapid growth of water spinach is presumed to be due to adequate total nitrogen derived from the snakehead culture medium, which is required as a nutrient source for plant growth. Water spinach treated with probiotics exhibited optimal growth because the plants were able to utilize nitrate produced from the oxidation of ammonia by bacteria to increase their biomass. As a result, organic matter in the culture medium can be properly accumulated, contributing to more stable water quality. The more inorganic nitrogen absorbed by the plants, the faster the growth rate and the lower the toxicity in the culture system (Rismoni et al., 2022).

CONCLUSION

The application of biofloc–aquaponic technology (biofloqua) can be carried out by constructing a circular grow-out tank equipped with ropes and wires attached to the upper part of the tank to hold charcoal and water spinach. Each tank is fitted with five aeration points, and molasses along with wetland-derived probiotics are added as starters. Snakehead fish (*Channa striata*) are stocked and acclimated, then fed commercial feed three times a day along with a protein diet. Water spinach seeds are sown on rockwool substrate in a humid, shaded room, and once roots and several leaves emerge, the seedlings are transferred into aquaponic trays.

The implementation of Biofloc and aquaponic (biofloqua) technology can enhance the survival rate of snakehead fish (*Channa striata*). The integration of biofloqua technology can serve as a simple culture system capable of producing both fish and vegetables.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the research, writing or publication of this article in BIOPENDIX: Journal of Biology, Education and Applications. The author ensures that there are no financial, institutional or personal relationships that influenced the process and results of writing this manuscript.

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