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CHARACTERISTICS OF WATER QUALITY AND GROWTH PERFORMANCE OF VANNAMEI SHRIMP (*Litopenaeus vannamei*) IN A HOUSEHOLD-SCALE BIOFLOC SYSTEM IN ALUE NAGA BANDA ACEH

KARAKTERISTIK KUALITAS AIR DAN PERFORMA PERTUMBUHAN UDANG VANAME (*Litopenaeus vannamei*) PADA SISTEM BIOFLOK SKALA RUMAH TANGGA DI ALUE NAGA BANDA ACEH

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Abstract

This study aimed to analyze the water quality characteristics and growth performance of vannamei shrimp (*Litopenaeus vannamei*) cultured in a household-scale biofloc system in Alue Naga, Banda Aceh. Observations were conducted in two round ponds over an 80-day culture period, covering water quality parameters (temperature, pH, dissolved oxygen, salinity, transparency, and floc volume) and growth parameters (ABW, ADG, survival rate, and FCR). The results showed that all water quality parameters remained within the optimal range for vannamei shrimp culture, with mean temperatures of 27.25±0.91°C (Pond 1) and 27.83±0.69°C (Pond 2), pH of 7.35±0.15 and 7.34±0.13, and dissolved oxygen of 6.53±0.30 and 6.49±0.26 mg/L. Shrimp growth performance showed a consistent increase in ABW from 1.6 and 1.4 g to 12.3 and 11.7 g at DOC 80, with ADG ranging from 0.14–0.26 g/day and relatively efficient FCR values (0.95 and 1.02). However, the survival rate declined to 52% and 57%, lower than the ideal target of 80%. These findings indicate that the household-scale biofloc system maintained stable water quality and supported satisfactory shrimp growth, although the survival rate remains a limiting factor requiring further improvement.

Keywords: *Vannamei shrimp, biofloc, water quality, growth performance, probiotics.*

Abstrak

Penelitian ini bertujuan untuk menganalisis karakteristik kualitas air dan performa pertumbuhan udang vaname (*Litopenaeus vannamei*) yang dibudidayakan dalam sistem bioflok skala rumah tangga di Alue Naga, Banda Aceh. Pengamatan dilakukan pada dua kolam bundar selama periode pemeliharaan 80 hari, meliputi parameter kualitas air (suhu, pH, oksigen terlarut, salinitas, kecerahan, dan volume flok) serta parameter pertumbuhan (ABW, ADG, tingkat kelangsungan hidup, dan FCR). Hasil penelitian menunjukkan bahwa seluruh parameter kualitas air masih berada pada kisaran optimal untuk budidaya udang vaname, dengan rata-rata suhu 27,25±0,91°C (Kolam 1) dan 27,83±0,69°C (Kolam 2), pH 7,35±0,15 dan 7,34±0,13, serta oksigen terlarut 6,53±0,30 dan 6,49±0,26 mg/L. Performa pertumbuhan udang menunjukkan peningkatan ABW yang konsisten dari 1,6 dan 1,4 g menjadi 12,3 dan 11,7 g pada DOC 80, dengan ADG berkisar 0,14–0,26 g/hari serta nilai FCR yang cukup efisien (0,95 dan 1,02). Namun, tingkat kelangsungan hidup menurun menjadi 52% dan 57%, lebih rendah dari target ideal sebesar 80%. Temuan ini menunjukkan bahwa sistem bioflok skala rumah tangga mampu menjaga kestabilan kualitas air dan mendukung pertumbuhan udang yang baik, meskipun tingkat kelangsungan hidup masih menjadi faktor pembatas yang perlu ditingkatkan.

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Kata Kunci: Udang vaname, bioflok, kualitas air, pertumbuhan, probiotik.

INTRODUCTION

Vannamei shrimp (*Litopenaeus vannamei*) is one of the leading aquaculture commodities with high economic value and is widely developed in Indonesia (Wiranata *et al*., 2022). The advantages of vannamei shrimp, including rapid growth, tolerance to environmental changes, and high market demand, have contributed to the continuous expansion of its aquaculture production (Syaputra *et al*., 2018; Samawi *et al*., 2021).

The increase in vannamei shrimp production is generally achieved through intensive aquaculture systems with high stocking densities. However, such systems face several challenges, particularly increased production costs due to high feed inputs and the accumulation of organic matter and nitrogenous waste, which can deteriorate water quality. Suboptimal water quality conditions may inhibit growth, reduce survival rates, and increase the risk of production failure (Shilman *et al*., 2025).

One of the technologies developed to overcome these challenges is the biofloc system. Biofloc technology utilizes the activity of heterotrophic microorganisms to convert inorganic nitrogen waste into microbial biomass in the form of flocs, which can serve as an additional feed source for shrimp (Gunarto *et al*., 2012). The application of biofloc systems has been reported to improve water quality, enhance feed efficiency, and support the growth performance of cultured organisms (Zulfahmi *et al*., 2018).

The application of biofloc technology at the household scale has become an alternative approach for developing vannamei shrimp culture with lower land requirements and production costs. One of its applications is the use of round ponds with a biofloc system in Alue Naga, Banda Aceh. However, the success of household-scale biofloc systems is highly influenced by the stability of water-quality parameters and shrimp growth responses throughout the culture period. Therefore, an assessment of water quality characteristics and the growth performance of vannamei shrimp in household-scale biofloc systems is needed to evaluate the effectiveness of this technology. This study aimed to analyze the water quality characteristics and growth performance of vannamei shrimp (*Litopenaeus vannamei*) cultured using a household-scale biofloc system in Alue Naga, Banda Aceh.

RESEARCH METHODS

This study employed direct observation in two 8 m diameter culture ponds located in an independent vannamei shrimp farming unit using a biofloc system in Alue Naga, Banda Aceh. Vannamei shrimp were cultured in round ponds, and their growth performance and water quality characteristics were monitored during 60 days of culture (DOC 60).

Tools

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The tools used in this study were a measuring cylinder, a Secchi disk, a refractometer, a pH meter, a DO meter, a digital scale, and an Imhoff cone.

Materials

The materials used in this study were vannamei shrimp postlarvae, commercial feed, probiotics (*Lactobacillus* sp. and *Bacillus* sp.), molasses, yeast, and rice bran.

Procedure

Preparation of Biofloc Culture System

The biofloc system was established through a fermentation process (Dahlan *et al.*, 2017). The materials used for floc formation included organic carbon and nitrogen sources, such as molasses, rice bran, and probiotics, along with supporting materials, such as yeast, to facilitate the fermentation process. The fermentation process was carried out for 24 hours. The fermented mixture was then applied to the culture ponds. Floc formation occurred over 4 days and was supported by an adequate oxygen supply to ensure successful floc development (Sahendra *et al.*, 2023).

Shrimp Stocking

Vannamei shrimp postlarvae (*Litopenaeus vannamei*) were stocked into the biofloc ponds after the rearing media reached suitable conditions. Prior to stocking, the postlarvae were acclimatized for 15 minutes to minimize stress caused by environmental changes (Dara *et al.*, 2023). The stocking density was 508 individuals m^{-3} per pond.

Biofloc Maintenance

Probiotic supplementation was administered every 3 days to maintain floc formation. Aeration was continuously maintained to support microbial activity and sustain dissolved oxygen levels in the culture media. Floc volume was monitored daily.

Water Quality Monitoring

Water quality observations were conducted daily in the morning and afternoon (07:30 AM and 04:30 PM WIB) throughout the 80-day culture period. The observed water quality parameters included temperature, pH, dissolved oxygen (DO), salinity, and water transparency.

Growth Performance Observation

Growth performance observations were conducted through sampling every 10 days. The growth parameters evaluated included Average Body Weight (ABW), Average Daily Growth (ADG), Survival Rate (SR), and Feed Conversion Ratio (FCR) Bahri *et al.*, (2020). The data obtained were used to evaluate the effectiveness of implementing a biofloc system on the production performance of vannamei shrimp.

Data Analysis

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Water quality and vannamei shrimp growth performance data were analyzed descriptively by presenting mean values, standard deviations, and graphs illustrating parameter changes throughout the culture period. The results obtained were compared with optimal ranges reported in the relevant literature.

RESULTS AND DISCUSSION

Characteristics of Water Quality in Biofloc System

The water quality parameters observed during the culture period are presented in Table 1. The measured parameters included temperature, pH, dissolved oxygen (DO), salinity, and water transparency. Overall, the water quality conditions in the biofloc system remained within the suitable range for vannamei shrimp culture.

Table 1. he water quality parameters observed during the culture period

Parameter	Pond 1 (Mean ± SD)	Min–Max	Pond 2 (Mean ± SD)	Min–Max
Dissolved oxygen (mg/L)	6.53 ± 0.30	5.80–7.00	6.49 ± 0.26	5.80–7.00
Salinity (ppt)	28.56 ± 1.77	20.00–32.00	28.24 ± 1.78	24.00–32.00
pH	7.35 ± 0.15	7.07–7.86	7.34 ± 0.13	7.04–7.62
Water transparency (cm)	35.06 ± 3.12	27.00–40.50	34.77 ± 2.48	30.00–40.00
Floc volume (mL/L)	72.41 ± 15.58	30.50–100.00	73.27 ± 16.80	40.00–110.00
Temperature (°C)	27.25 ± 0.91	24.70–29.40	27.83 ± 0.69	26.50–30.50

Temperature is one of the water quality parameters that plays an important role in shrimp culture because it affects metabolic activity, feed consumption, and growth (Yulihartini et al., 2017). During the study, water temperature in pond 1 ranged from 24.70–29.40 °C, with an average of 27.25 ± 0.91 °C, and in pond 2, from 26.50–30.50 °C, with an average of 27.83 ± 0.69 °C. These temperature ranges were still close to the optimal conditions for vannamei shrimp culture. According to Santanumurti *et al.* (2019), the optimal temperature range for the growth and survival of vannamei shrimp is between 28–30 °C.

During the culture period, water temperature occasionally decreased below the optimal range. This condition was presumably influenced by high rainfall intensity, which reduced the temperature of the culture medium. A decrease in temperature may reduce shrimp metabolic rates and feeding activity, potentially inhibiting growth performance (Supito, 2017). Nevertheless, the temperature fluctuations during the study remained within the tolerance range for vannamei shrimp and did not significantly affect growth performance. This indicates that the biofloc system maintained relatively stable environmental conditions throughout the rearing period.

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pH is one of the water quality parameters that affect shrimp physiological processes, including feeding activity, metabolism, and molting. During the study, pH values in pond 1 ranged from 7.07 to 7.86, with an average of 7.35 ± 0.15, and in pond 2, from 7.04 to 7.62, with an average of 7.34 ± 0.13. These pH ranges were still within suitable conditions for vannamei shrimp culture. According to Zulfahmi *et al.* (2018), the optimum pH range for vannamei shrimp growth is 7.0–8.5.

pH conditions within the optimum range support shrimp metabolic activity and feed consumption, allowing growth to proceed properly. In contrast, pH values below the tolerance range may disrupt the molting process, cause soft exoskeleton formation, and reduce shrimp survival rates (Arsad *et al.*, 2017). The stability of pH values was presumably related to the activity of microorganisms in the biofloc system, which assisted in the decomposition of organic matter and maintained the balance of biogeochemical processes in the culture medium. In addition, continuous aeration helped maintain pH stability throughout the rearing period.

During the rearing period, dissolved oxygen (DO) values ranged from 5.80–7.00 mg/L, with an average of 6.53 ± 0.30 mg/L in pond 1 and 5.80–7.00 mg/L, with an average of 6.49 ± 0.26 mg/L in pond 2. In biofloc-based shrimp culture systems, high dissolved oxygen levels are required to support the growth of beneficial bacteria responsible for floc formation. According to Farchan (2006), the suitable DO range for shrimp growth is 4–8 mg/L.

During the culture period, water salinity ranged from 20–32 ppt in pond 1 and 24–32 ppt in pond 2. Shrimp are euryhaline organisms, meaning they have a wide tolerance range to salinity, ranging from 3–45 ppt (Febriani et al., 2018). Vannamei shrimp can grow well at salinity levels of 10–30 g L^{-1} (Arsad *et al.*, 2017; Purnamasari *et al.*, 2017).

Water transparency measured during the rearing period ranged from 27–40 cm in pond 1 and 30–40 cm in pond 2. The optimal transparency level for shrimp growth is 20–40 cm above the water surface (Arsad *et al.*, 2017). Fluctuations in water transparency were due to variations in the density of flocs in the culture medium.

During the culture period, floc volume measurements ranged from 30–100 mL/L (3–10% of the total culture medium volume) in pond 1, while in pond 2, floc volume ranged from 40–110 mL/L (4–11% of the total culture medium volume). Based on these results, the floc volume in the Alue Naga independent aquaculture facility was considered good. Floc volume measurement aims to determine floc density, which vannamei shrimp can subsequently utilize as a natural feed source (Pantjara *et al.*, 2010). This is in accordance with Dahlan *et al.* (2019), who stated that probiotic bacterial communities accumulated in heterotrophic aquaculture systems form flocs (aggregates) that can be utilized as a feed source for shrimp.

Growth Performance of Vannamei Shrimp

The growth performance of vannamei shrimp cultured in the biofloc system during the 80-day rearing period is presented in Table 2. The observed parameters included average body weight (ABW), average daily growth (ADG), survival rate (SR), and feed conversion ratio (FCR), which were first measured at DOC 30 and subsequently recorded every 10 days for both ponds.

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Table 2. Growth Performance of Vannamei Shrimp During Biofloc Culture

DOC	ABW (g.ind^{-1})		ADG (g.day^{-1})		SR (%)		FCR	
	Pond 1	Pond 2	Pond 1	Pond 2	Pond 1	Pond 2	Pond 1	Pond 2
30	1.6	1.4	-	-	83	88	1.02	1.10
40	3.2	2.8	0.16	0.14	78	78	0.86	0.95
50	5.4	4.9	0.22	0.21	67	73	0.93	0.85
60	7.3	6.7	0.19	0.18	62	67	0.93	0.96
70	9.7	9.1	0.24	0.24	55	62	0.97	1.02
80	12.3	11.7	0.26	0.26	52	57	0.95	1.02
Mean	6.6	6.1	0.21	0.21	66.2	70.8	0.94	0.98

The observation results showed that vannamei shrimp exhibited increased growth throughout the culture period in the household-scale biofloc system. The average body weight (ABW) of shrimp in pond 1 increased from 1.6 g ind^{-1} to 12.3 g ind^{-1}, while in pond 2 it increased from 1.4 g ind^{-1} to 11.7 g ind^{-1} at the end of the culture period (DOC 80). The average daily growth (ADG) values in both ponds ranged from 0.14–0.26 g ind^{-1} day^{-1}. The increase in ABW and ADG indicates that the environmental conditions in the biofloc system supported metabolic processes and vannamei shrimp growth. The growth of vannamei shrimp is strongly influenced by the availability of balanced feed and water quality (Aisyah *et al.*, 2023).

The growth performance of shrimp in the biofloc system was presumably associated with the presence of microbial communities within the flocs, which function as an additional nutrient source. Bioflocs consist of aggregates of microorganisms, organic matter, and inorganic compounds that shrimp can utilize as supplementary natural feed (Noor & Aziz, 2023). The presence of bioflocs can increase the availability of microbial protein, thereby supporting feed utilization efficiency and shrimp growth.

The survival rate (SR) at the end of the culture period (DOC 80) reached 52% in pond 1 and 57% in pond 2. The decrease in SR during the culture period may be attributed to increased shrimp biomass, which can lead to greater competition for space, increased oxygen requirements, and the accumulation of organic matter in the culture media (Hidayat *et al.*, 2014). According to Prihatini *et al*. (2013), a good shrimp survival rate is approximately 80%; therefore, the SR obtained in this culture system was considered relatively low. Nevertheless, the biofloc system still supported shrimp survival through the end of the culture period.

Based on the feed conversion ratio (FCR) calculation, the FCR values at DOC 80 were 0.95 in Pond 1 and 1.02 in Pond 2. According to Lailiyah *et al.* (2018) and Hendriana (2020), a good FCR value for vannamei shrimp should not exceed 1.5. These values indicate that the feed provided was utilized efficiently to support shrimp biomass production. The low FCR values obtained in the biofloc system were presumably due to the contribution of flocs as an additional

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natural feed source, thereby reducing dependence on formulated feed. This finding is consistent with Pantjara *et al. (2010),* who reported that biofloc technology improves water quality and feed efficiency by 10–20%. A lower FCR value indicates better feed quality and utilization efficiency, as it reflects that the amount of feed consumed exceeds the amount of uneaten feed remaining (Supono *et al.*, 2021).

Overall, the growth performance observed in both ponds indicates that the household-scale biofloc system maintained environmental conditions conducive to shrimp culture. Stable temperature, dissolved oxygen, salinity, and pH supported normal physiological processes, while biofloc provided an additional nutrient source that enhanced feed utilization. Consequently, shrimp exhibited continuous weight gain, satisfactory daily growth, and relatively low FCR throughout the culture period. Although the survival rate gradually declined as the culture progressed, the overall performance suggests that the biofloc system can support vannamei shrimp production under household-scale culture conditions.

CONCLUSION

This study demonstrated that the household-scale biofloc system in Alue Naga, Banda Aceh, maintained water quality parameters (temperature, pH, dissolved oxygen, salinity, transparency, and floc volume) within the optimal range for vannamei shrimp culture throughout the 80-day rearing period. Growth performance was reflected in the consistent increase in average body weight from 1.6–1.4 g to 12.3–11.7 g, average daily growth of 0.14–0.26 g/day, and relatively efficient feed conversion ratios (0.95–1.02) in both ponds, indicating effective utilization of biofloc as a supplementary natural feed source. Nevertheless, the survival rate obtained (52–57%) was still lower than the ideal standard of 80%, suggesting that biomass accumulation, competition for space, and organic matter buildup during later culture stages remain limiting factors. Overall, the household-scale biofloc system proved effective in maintaining stable water quality and supporting satisfactory shrimp growth. However, further improvements in stocking-density management and system control are needed to increase survival rates.

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