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Evaluation of Flock Volume Levels on Water Quality and Production Performance of Catfish (*Clarias gariepinus*) Cultured Using a Micropore Pipe as an Aeration Diffuser

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Abstract

High floc accumulation in intensive catfish culture will increase the bacterial consumption of oxygen, causing the dissolved oxygen in the media to be relatively low and affect the fish growth. The control is to remove floc sediments regularly. However, removing a large amount of floc sediment will affect the flock's ability to control nitrogen waste in the rearing media, and the utilization of the flock as feed for fish will be minimal. This research was conducted to evaluate the level of floc volume on water quality and production performance of catfish *Clarias gariepinus* cultured in the biofloc system. The research design used a completely randomized design (CRD) with 4 treatments and 3 replications. The research treatments included floc volume density (FVD) at 20-40 ml/L, (FVD) 40-60 ml/L, (FVD) 60-80 ml/L and (FVD) 80-100 ml/L. The results showed that the water quality in all treatment was within the safe level for catfish. (FVD) 60-80 ml/L and 80-100 ml/L had higher survival rates of 100% ($P < 0.05$). (FVD) 80-100 ml/L showed the lowest growth rate value compared to other treatments ($P < 0.05$). (FVD) 60-80 ml/L could improve feed conversion ratio and increase protein retention by 59.17%, significantly different from other floc level treatments ($P < 0.05$). Overall, the results showed that a floc volume density of 60-80 ml/L was more suitable for catfish culture in a biofloc system.

INTRODUCTION

High concentration of floc (biofloc) volume in intensive fish culture will increase the consumption of oxygen of heterotrophic bacteria, which causes the dissolved oxygen content of the rearing media to be low and the fish growth to be slow (Ebeling *et al.,* 2006). Efforts to improve aeration to increase the dissolved oxygen content in the biofloc system have been studied previously by applying a micropore pipe as an aeration diffuser on the catfish rearing media in the biofloc system, which finally produced a linear micropore diffuser which is more effective at maintaining dissolved oxygen content in optimal conditions compared to using aeration stone coarse diffusers (Sumitro *et al.,* 2020).

The problem faced is that the increase in floc volume density is very fast, especially at the end of fish rearing, which is caused by an increase in the assimilation of nitrogen (N) waste by heterotrophic bacteria and an increase in the addition of

carbon into the rearing media. The consequence of high floc densities will result in the deterioration of water quality, namely a decrease in dissolved oxygen. Harris (2010) stated that goldfish reared in saturated oxygen conditions grew 1.5 faster than goldfish reared in fluctuating dissolved oxygen conditions. Even fish fed the same feed at different oxygen conditions will result in different feed conversions (Huisman, 1986). Furthermore, the increase in floc solids also has a negative effect on the health and production of fish. Schveitzer *et al*. (2013) reported that floc solid particles in the range of 800-1000 mg/L caused clogging in the gills of shrimp, which resulted in low viability of vannamei shrimp. Therefore, it is very necessary to control the level of the floc volume by removing the floc sediment. However, removing large amounts of floc particles will affect the floc's ability to control nitrogen waste, and the opportunity to utilize floc as additional feed for fish will be minimal. Thus, it is necessary to know the range of floc volume levels that are suitable for catfish culture with biofloc systems, so that water quality is maintained and the floc remains available in the rearing media, which ultimately supports the growth and survival of catfish.

One of the techniques used to measure the volume level of floc (biofloc) is by measuring the total suspended solids (TSS) in the water (De Schryver *et al.,* 2008). Schveitzer *et al*. (2013) conducted control of total suspended solids (TSS) particles in vannamei shrimp culture with a maximum TSS concentration of 600 mg/L which is more suitable for vannamei shrimp culture with biofloc systems. However, TSS observations require time for TSS testing in the laboratory so it is less applicable for field and mass scale catfish cultivators. A simpler approach is to measure the volume of the flock directly using a centrifuge at the culture site. Observation of floc volume will explain how much floc density is in fish rearing ponds. Therefore, it is highly necessary to conduct a study on the regulation of floc volume, which is expected to obtain an image of the floc density which is suitable for catfish culture with a biofloc system using a micropore pipe aeration diffuser.

METHODOLOGY

Place and Time

This research was conducted for 2 months in October-December 2020 at the Laboratory of the Aquaculture Study Program, Faculty of Fisheries and Marine Sciences, Dayanu Ikhsanuddin University Baubau.

Research Materials

The research containers were 12 units of plastic drums with a diameter of 180 cm and a height of 46 cm, digital scales, and blowers. Aeration diffuser was a micropore pipe from China with a density of 700-1200 holes/m which was formed linearly (L) with an inner diameter of microporous pipe of 10 mm and an outer diameter of 16 mm. Observation of water quality was done using some equipment, among others: DO meter (Lutron DO-5519), pH meter (pHep Hanna), thermometer, and 50 ml centrifuge tube (floc volume measuring instrument). Meanwhile, observations of TAN, nitrite, nitrate, and alkalinity were conducted using the APHA (1998) method.

The experimental animals were catfish with a bodyweight range of 4±0.37 g, and this study also used commercial pellet feed (protein content of 30%), tapioca flour (40% C) as a carbon source, and a probiotic from INVE Belgium (Sanolife Pro-W) containing bacteria strains of *Bacillus subtilis* and *Bacillus licheniformis*.

Research Design

This study used a completely randomized design (CRD) with 4 treatments and 3 replications. The treatments applied were floc volume density, namely floc volume density 20-40 ml/L (FVD 20-40), floc volume density 40-

60 ml/L (FVD 40-60), (FVD 60-80) and (FVD 80-100).

Work Procedure

The research containers which were plastic drums with a diameter of 180 cm and a height of 60 cm were cleaned and filled with 20 liters of water and then sterilized using 15 ppm chlorine. Afterward, it was aerated vigorously for 2-3 days until the smell of chlorine disappeared. The micropore pipe used had a diameter specification of 16 mm and an inner hole diameter of 10 mm, with a density of 700-1200 holes/m.

In the floc culture using probiotics, probiotics were added to the rearing media with a concentration of 10 mg/L, and 0.5 g/L NH4Cl was also added as a source of N. The carbon source was tapioca flour with the targeted C/N ratio of 10. Subsequently, the media were aerated for ± 7 days until the floc was formed and TAN = 0 mg/L, and then the adjustment of floc density according to the treatment was performed in each tank.

Catfish seeds were stocked into rearing tanks at a density of 20 fish/tank or 1000 fish m^{-3}. Fish rearing was carried out for 56 days. During rearing the fish were given commercial feed containing 30% protein. The frequency of feeding was three times a day, specifically in the morning at 07.00 WITA, in the afternoon at 15.00 WITA and in the evening at 23.00 WITA. Feeding was done at satiation.

During the study, carbon was added using tapioca with a carbon content of 40%, which was added every day in the morning before feeding. The procedure for adding carbon refers to Avnimelech's (1999) method. Flock volume control was carried out every day. The adjustment of the volume of the floc was conducted by removing the floc sediment regularly to maintain the range of floc volume according to each treatment. The volume of the floc was measured using a 50 ml volume centrifuge tube after going through the precipitation process for 15 minutes. The floc volume calculation used the following formula:

$$\text{Floc Volume (ml/L)} = \frac{\text{sediment volume}}{\text{water sample volume}} \times 1000$$

Every 14 days water observation was carried out to observe water quality, and fish samples were used to measure fish weight. The sampling of fish for analysis of protein retention was conducted at the beginning and end of the study. To determine the fish growth and survival the fish were weighed, and the number of live fish during rearing was counted.

The specific growth rate (SGR) was calculated using the Huisman's (1987) formula:

$$SGR = \left[\sqrt[t]{\frac{Wt}{Wo}} - 1\right] \times 100$$

Where:
SGR = specific growth rate (%/day)
Wt = average final weight (g)
Wo = average initial weight (g)
t = culture period (days)

Feed conversion ratio (FCR) was calculated according to the formula from Goddard (1996):

$$FCR = \frac{F}{Wt + Wd - Wo}$$

Where:
FCR = feed conversion ratio
Wt = final fish biomass (kg)
Wd = dead fish biomass (kg)
Wo = initial fish biomass (kg)

Protein retention was calculated using the formula from Watanabe (1988):

$$PR = \frac{F - I}{P} \times 100$$

Where:
PR = protein retention (%)
F = total protein at the end of rearing (g)
I = amount protein at the beginning of rearing (g)
P = feed protein consumed (g)

Data Analysis

Data of the production performance obtained during the study were analyzed using analysis of variance (ANOVA) with the SPSS 21.1 program at a 95% confidence interval. If the results were significantly different, the Tukey test

would be performed. Water quality data were analyzed descriptively.

RESULTS AND DISCUSSION

Water Quality

Table 1. Value of water quality of catfish culture media at different floc volume densities using a micropore pipe diffuser.

Parameter	Floc Volume Density (FVD)			
	20-40 ml/L	40-60 ml/L	60-80 ml/L	80-100 ml/L
Dissolved oxygen (mg/L)	3.0-4.8	3.0-4.6	2.8-4.0	2-3.2
Temperature (°C)	26-30	26-30	26-30	26-30
TAN (mg/L)	0.024-0.037	0.010-0.032	0.027-0.029	0.020-0.019
Nitrite (mg/L)	0.027-0.036	0.016-0.042	0.022-0.033	0.034-0.040
Nitrate (mg/L)	0.034-0.232	0.032-0.235	0.038-0.236	0.029-0.261
pH	6-7.5	6-7.2	6-7.2	6-7.4
Alkalinity (mg/L)	74.21-80.63	65.33-82.26	69.42-84.32	58.26-79.24

The results of the observation showed that the lowest dissolved oxygen value was at the floc volume density (FVD) of 80-100 ml/L, which ranged from 2-3.2 mg/L. The increase in floc volume causes the oxygen consumption of heterotrophic bacteria to increase and causes the dissolved oxygen content of the rearing media to be low (Ebeling *et al*., 2006). The results of the temperature observation ranged from 26-30 °C and were still in the range that was supportive for catfish cultivation (Sutomo, 2000).

The TAN concentration obtained in this study has not yet provided a toxic effect for fish (Firman *et al.*, 2019). This proves that the ammonia mineralization process is running well even at a low floc density of 20-40 ml/L. Bakar *et al.* (2015) stated that the addition of a carbon source was able to reduce ammonia by 98.7% in catfish farming using biofloc technology. The concentration of nitrite and nitrate showed that the nitrification process occurred in all rearing media. Nitrite is an intermediate product from ammonia to nitrite, which is then converted by nitrifying bacteria into nitrate. The availability of nitrifying bacteria in the rearing media will increase the nitrification process so as to maintain the concentration of ammonia and nitrite at a level that is safe for fish (Zaki *et al*., 2020; Dawood *et al*., 2021).

The pH values obtained in all treatments ranged from 6 to 7.5. The lowest pH value of 6 might be due to the influence of respiration from heterotrophic bacteria, thereby increasing the concentration of CO_2 in the rearing media (AftabUddin *et al*., 2020). However, the pH value in this study was still within the appropriate range for catfish growth.

The results of the alkalinity measurement were in the range of 58.26 - 79.24 mg/L. The value of the alkalinity range is still supportive for the growth of catfish, which is in the range of 30-500 mg/L (Boyd and Tucker, 1998).

Production Performance

Table 2. Production performance of catfish at different floc volume densities.

Production Performance	Floc Volume Density (FVD)			
	20-40 ml/L	40-60 ml/L	60-80 ml/L	80-100 ml/L
SR (%)	97.00 ± 1.00^{b}	98.00 ± 2.87^{b}	100 ± 0.00^{a}	100 ± 0.00^{a}
SGR (% /day)	5.37 ± 0.30^{a}	5.19 ± 0.11^{a}	5.20 ± 0.20^{a}	4.56 ± 0.20^{b}
FCR	0.85 ± 0.02^{b}	0.83 ± 0.02^{ab}	0.79 ± 0.03^{a}	0.92 ± 0.02^{b}
PR (%)	45.55 ± 0.87^{b}	47.30 ± 2.07^{b}	59.17 ± 0.76^{a}	47.29 ± 1.05^{b}

Notes: Values followed by different letters on the same row indicates significant differences ($p<0.05$).

The results of this study showed that the survival rate (SR) of catfish was different between treatments (P<0.05). Catfish at floc densities of 20-40 ml/L and 40-60 ml/L had lower survival rates than fish at (FVD) 60-80 ml/L and (FVD) 80-100 ml/L, which might be due to cannibalism during rearing. High fish density causes competition for space and food, which ultimately increases aggression between fish and leads to fish death (Manley *et al*., 2014). One way to reduce the level of cannibalism is by performing grading once during the rearing period (Engle *et al*., 2011).

The results of the observation showed that catfish had the average specific growth rate (SGR) which was lower at (FVD) 80-100 ml/L (P<0.05). This is presumably because the dissolved oxygen concentration available in the 80-100 ml/L treatment was not as high as that in the rearing media at (FVD) 20-40 ml/L, 40-60 ml/L, and 60-80 ml/L, thereby affecting fish metabolism. According to Harris (2010) and Welker *et al*. (2013), an increase in the dissolved oxygen in the rearing media can accelerate the metabolic rate of fish, which ultimately increases fish growth.

The value of feed conversion ratio (FCR) and protein retention (PR) showed that catfish reared at a floc density of 60-80 ml/L had significantly different values from fish at other treatments (P<0.05). This could be due to the high availability of floc and more stable oxygen content in the rearing media so that fish could utilize the floc optimally, which in turn resulted in good FCR. (Gao *et al*., 2012; Xu *et al*., 2012). The results also showed that the ingested floc was able to be used well by fish for the synthesis of body protein. Ekasari *et al*. (2014) stated that biofloc has a high quality protein source and has a high composition of essential amino acids in valine, lysine, leucine, phenylalanine and threonine.

CONCLUSION

Floc volume density of 60-80 ml/L is more suitable for catfish culture with biofloc systems because it can improve the water quality of the rearing media, increase fish survival and growth, improve feed conversion ratio and increase high protein retention during the study.

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