Enhancing catfish (Clarias sp.) farming production and economic viability through molasses application in biofloc system

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ABSTRACT

In addition to having high economic value, catfish (Clarias sp.) can also be cultivated quickly and they can adapt well. The demand for catfish is in line with the increase in production which is expected to remain efficient and environmentally sound. Biofloc technology has also been implemented in catfish to increase productivity. Biofloc utilizes the activity of heterotrophic microorganisms and autotrophs for the conversion of organic waste into floc and is used as fish feed. This study aims to examine the effect of the use of molasses with different doses (C/N ratio) on the growth and survival rate of catfish. This study was conducted with as many as 4 treatments with 3 repetitions each. The treatment with the ratio of molasses in each of them: A: C/N ratio of 10:1; B: C/N ratio of 15:1; C: C/N ratio of 20:1, and D without molasses given as control. The study using 240 catfish measuring 10-12 cm (8.8 g) was carried out for 30 days with sampling every 10 days. It aims to determine the average growth, daily growth, and survival rate of test biota during the study. Based on the results of this study, it can be concluded that the use of different doses of molasses in catfish farming, and biofloc technology will affect the growth and survival rate of farmed catfish. Catfish farmed with biofloc technology at a C/N ratio of 15:1 show the best results on their growth and survival rate. In addition, catfish farming with a biofloc C/N ratio of 15:1 has a better economic analysis when compared to conventional catfish farming. In summary, the use of biofloc based on research results can be a recommendation to be applied in the community, especially among catfish farmers.

Introduction

Catfish (Clarias sp.) is one of the freshwater aquaculture commodities with high economic value (Putra et al., 2022; Putra et al., 2023), its rapid growth, as well as its adaptability to the environment, is high (Sitio et al., 2017). The demand for catfish has increased from year to year along with the increase in production (Soares, 2011). Based on data released by Satu Data KKP (Retrieved, 2023), the total production of Indonesian catfish in 2016 amounted to 764,796.83 tons and increased by 47.16% or 1,125,526.35 tons in 2017. With the rising freshwater fish farming production, it has become essential to conduct environmentally friendly aquaculture operations that are intensive, efficient, and characterized by minimal waste discharge into surrounding waters (Aiyushirota, 2009).

Catfish farming has been developed conventionally. Along with the development of technology, discoveries in various fields can be felt, for instance, biofloc technology in the aquaculture sector (Sitorus et al., 2019). Biofloc is a group of microorganisms that float in water in the form of small lumps which are formed and occur under

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certain environmental conditions (Dewi and Ulfah, 2022). Biofloc utilizes the activity of heterotrophic microorganisms and autotrophs for the conversion of organic waste into floc and is used as fish feed. The floc consists of several forming organisms such as bacteria, plankton, fungi, algae, and suspended particles that affect the structure and nutrition of the biofloc (Nugraha et al., 2022). The application of biofloc in several fish species has several advantages including increased production by improving growth performance and survival rate (Kurniawan and Atriani, 2016), increased physiological activity of fish farming, and improved nutrient utilization, avoiding environmental stress, and predation (Zaidy and Eliyani, 2021). Furthermore, the biofloc system can overcome the problem of intensive system cultivation by converting nitrogenous waste into a mass of microbes that can be consumed by fish (Rahmatullah et al., 2020).

Probiotic bacteria have been utilized in shrimp farming for the conversion of organic matter into natural feed, representing an early milestone in the establishment of biofloc technology within the field of aquaculture (McIntosh, 2000). Along with its development, probiotics for the biofloc system are also used in catfish farming. Technically, the implementation of biofloc technology is carried out by adding organic carbohydrates to the maintenance media to increase the ratio of carbon and nitrogen (C/N) and stimulate the growth of heterotrophic bacteria that can assimilate inorganic nitrogen into bacterial biomass (Avnimelech, 2015). The C/N ratio is required to balance water conditions in the biofloc cultivation system (Suprapto, 2013). The application of technology to the C/N ratio is in the form of biotechnology because it activates the work of heterotroph microbes. The relationship of the C/N ratio with the mechanism of action of bacteria is that bacteria obtain food through carbon and nitrogen substrates with a certain ratio. Heterotrophic bacteria are known to convert aquaculture ammonia-nitrogen waste into potential bacterial biomass as a source of feed for fish (Toi et al., 2013).

Molasses is the final waste of the sugar processing process after repeated crystallization and is blackish-brown and in the form of a viscous liquid. Molasses has been widely used as a carbon source for denitrification processes, anaerobic fermentation, waste conversion, to aquaculture activities (Schneider et al., 2006). Biofloc contains 39-48% protein, 12-24% fat, 3-4% crude fiber, and 25-28% ash (Widanarni et al., 2012). This content can be used as an alternative source of high-protein natural feed for fish and shrimp (Rahman et al., 2020). In addition, developing biofloc methods to increase the production and quality of catfish bags can produce 2,000 fish/m³ when compared to conventional methods which only produce 100 fish/m³ (Suparno and Qosim, 2016).

This study aims to examine the effect of the use of molasses with different doses (C/N ratio) on the growth and life level of catfish (Clarias sp.) through the biofloc system as an effort to increase the production of the species. This research also serves as an appeal to catfish farming businesses with biofloc systems to provide a general description to the public that technology in catfish farming businesses can provide better results compared to catfish farming businesses without a touch of technology.

Materials and Methods

Materials

The materials used in this study include 240 catfish (Clarias sp.) fry measuring 10-12 cm (8.8 g). These seeds are produced from the Jakarta Technical University of Fisheries Freshwater Fish Farming Hatchery, Lampung Campus. In addition, molasses, liquid probiotics, fish feed with a protein content of 35%, calcium hypochlorite of 60%, salt, and dolomite lime are also used.

Data Collection

This study was carried out for 30 days. There are two data used during the research process, namely primary data and secondary data. Direct primary data were collected during the study which included specific catfish growth data on weight and daily weight which were all measured once every 10 days. Then, also daily fish mortality data at the end of the study to determine the survival rate during the cultural process. While secondary data is obtained from references related to research materials both from print and electronic media.

Experimental Design

The study was conducted with as many as 4 treatments with 3 repetitions each. Each container was randomly distributed into one of the three replicates of four treatments. The treatments are:

A : Molasses given with a ratio of C/N 10:1
B : Molasses given with a ratio of C/N 15:1
C : Molasses given with a ratio of C / N 20:1
D : No molasses as a control

The experimental design used was a Complete Randomized Design (CRD) with a hypothesis:
**H₀**: The giving of molasses at different doses affects the formation of floc, growth and survival rate of catfish (*Clarias* sp.)

**H₁**: The giving of molasses at different doses does not affect the formation of floc, growth and survival rate of catfish (*Clarias* sp.)

**Data Analysis**

Data in this study were checked by a one-way ANOVA to test the effects of molasses treatments. When a significant treatment effect was observed, Tukey’s test was used to compare different treatments. The treatment effects were considered significant at the confidence level of *P*<0.05. Statistical analyses were performed using the SAS program package (version 9.4, SAS Institute Inc., Cary, NC, USA). Data was evaluated for assumptions, including normality and homogeneity of variance, using the Shapiro-Wilk and Levene’s tests, respectively.

**Experimental Procedure**

The research procedure includes two major stages, namely the preparation and implementation of research. The preparation stages utilized maintenance containers, aeration stones, aeration hoses, and regulators using 50 mg/L hypochlorite calcium. Maintenance containers in the form of buckets of 50 liters volume as many as 12 pieces. Installation of aeration on each maintenance container. Coding the experimental container was based on the research design. The experimental container was filled with water to a volume of 40 liters. Followed by utilizing water using calcium hypochlorite 100 mg/L. After 3 days, salt distribution was carried out at 2.5 g/L, and after 1 day dolomite was spread diluted with a dose of 1.5 g/L. After 1 day, molasses was stocked at a dose of 1 ml/L, and probiotics stocking at a dose of 0.25 ml/L. After the floc is formed (3 days) sampling of seeds to be stocked includes the weight and average length of seeds. The distribution of catfish fry measuring 10-12 cm (initial body weight of 8.8 g/fish) with a density of 20 fish/40 liter.

During the research process, the feed was carried out with a frequency of 3 times a day, namely at 06.00, 16.00, and 22.00 (Lampung-Indonesia Time). The feed used contains 35% protein. The amount of feed given is 5% of biomass on the first to 10th days, 4% of biomass on days 11 to 20, and on the 21st to harvest days of 3% of biomass. Furthermore, probiotics given as much as 0.25 ml/L every 3 days, molasses every 3 days with the amount of molasses calculated based on the number of daily feeds with different amounts, namely in treatment A with a C/N ratio of 10:1, treatment B with a C/N ratio of 15:1, and treatment C with a C/N ratio of 20:1. However, for the control treatment, probiotics given as much as 0.25 ml/L every 3 days without the addition of molasses. During maintenance, no water change is carried out, only the addition of water as much as the amount of water that evaporates. Catfish harvesting is carried out after 30 days of rearing.

**Results**

**Growth Parameters**

Based on research conducted for 30 days, the maintenance of biofloc farmed catfish (*Clarias* sp.) with different molasses treatments obtained the following results: the average growth of test biota, daily growth of test biota, and survival rate. Growth observation was carried out by measuring the average weight of catfish (average body weight). The results of average body weight observations are presented on the graph in Figure 1. The averages daily growth graph is shown in Figure 2.

![Figure 1. Average body growth of catfish.](image1)

![Figure 2. Average daily growth of catfish.](image2)

The average body weight and average daily growth in the test biota presented in Figure 1 and Figure 2, it can be seen that in the first sampling, catfish (*Clarias* sp.) farmed with C/N of 15:1 molasses treatment had better growth compared to no molasses treatment. However, daily growth treated with C/N of 10:1 and 20:1 molasses was almost the same as without treatment. On the other hand, in the second
sampling, all treatments experienced a decrease in daily growth. In the third sampling, catfish farmed with C/N of 10:1 and 20:1 molasses treatment and without molasses treatment experienced a decrease in daily growth from the second sampling while the C/N of 15:1 treatment increased.

Furthermore, from observations of the life level of catfish cultivated with a biofloc system with different molasses treatments for 30 days of maintenance, the life level of the test biota was obtained as illustrated in Figure 2. Results of this study, it can be seen that the growth of catfish cultivated with the application of molasses with a ratio of C/N 10:1 and 15:1 has better growth when compared to catfish cultivated without molasses treatment. Catfish farmed with molasses treatment with a C/N ratio of 20:1 have worse growth when compared to catfish without molasses treatment. The growth of catfish cultivated with a biofloc system with a ratio of C/N ratio of 15:1 has better growth when compared to other treatments.

Catfish cultivated with molasses treatment have a survival rate of 90-100% when compared to catfish without treatment, which is only 80% (Figure 3). The survival rate of the fish cultivated with a C/N ratio of 15:1 and a C/N ratio of 20:1 is significantly higher than the survival rate of the fish cultivated without molasses. However, there was no significant difference in survival rate between fish cultivated with a C/N ratio of 10:1 and fish cultivated without molasses.

**Production Comparison**

A comparison of production values is needed to reinforce the results of the research that has been done. This section compares three different things on several parameters. Value comparison refers to the cultivation scheme by not using biofloc, the average with the use of biofloc, and the best results in this research results are C/N ratio of 15:1. Details of the data are presented in Table 1.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Without Biofloc</th>
<th>Average with Biofloc</th>
<th>Biofloc C/N (15:1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (fish/40 liter)</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Duration of Maintenance (day)</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Initial Weight (g/fish)</td>
<td>8.8</td>
<td>8.8</td>
<td>8.8</td>
</tr>
<tr>
<td>Final Weight (g/fish)</td>
<td>16.4</td>
<td>17.0</td>
<td>18.6</td>
</tr>
<tr>
<td>Survival rate (%)</td>
<td>80</td>
<td>96.7</td>
<td>100</td>
</tr>
<tr>
<td>Initial Biomass (g)</td>
<td>176</td>
<td>176</td>
<td>176</td>
</tr>
<tr>
<td>Final Biomass (g)</td>
<td>262</td>
<td>329</td>
<td>372</td>
</tr>
<tr>
<td>Increased Biomass (g)</td>
<td>86</td>
<td>153</td>
<td>196</td>
</tr>
<tr>
<td>Growth Comparison (%)(^3)</td>
<td>-</td>
<td>78</td>
<td>128</td>
</tr>
</tbody>
</table>

\(^1\)Calculation based on the result data of this study.

\(^2\)Average data of C/N ratio of 10:1, C/N ratio of 15:1, C/N ratio of 20:1 in this study.

\(^3\)Calculated by compared with cultivation system without biofloc.

Cultivation systems using biofloc are highly recommended when compared to conventional systems or without biofloc. With the same density (2 fish/40 liters) and with the same maintenance duration of 30 days, different final weights and final biomass are obtained. This value will differ in the increase in biomass and the percentage of growth ratio in each system used. The final weight and final biomass in systems without biofloc were 16.4 g/fish and 262 g, from the same initial values as systems using both average and C/N of 15:1 biofloc of 8.8 g/fish and 176 g. On average, biofloc had a final weight of 17.0 g/fish and a final biomass of 329 g, while those using C/N of 15:1 were 18.6 g/fish and 372 g, respectively. The growth percentage of catfish cultivation by using biofloc with a C/N ratio of 15:1 was 128% compared with catfish cultivation without biofloc.

**Economic Analysis**

Referring to the results of the comparison of production values presented in Table 1 will certainly be in line with the economic analysis between systems without biofloc and with biofloc, especially C/N of 15:1 (Table 2). The production costs incurred in the biofloc system were above when compared to systems without biofloc. The cause was the molasses used. However, the sales results showed...
that there was a difference of IDR 25,600 between the system without biofloc and with biofloc. The profit value had a difference of IDR 13,100 or the profit of the biofloc system is 6-7 times when compared to the system without biofloc.

Table 2. Economic analysis of biofloc and non-biofloc systems

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Non-Biofloc</th>
<th>Biofloc (15:1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass of fish (kg)</td>
<td>1</td>
<td>2.28</td>
</tr>
<tr>
<td>Total of feed (kg)</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Molasses (kg)</td>
<td>-</td>
<td>2.5</td>
</tr>
<tr>
<td>Selling Price (IDR/kg)</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Feed Price (IDR/kg)</td>
<td>12,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Molasses Price (IDR/kg)</td>
<td>-</td>
<td>5,000</td>
</tr>
<tr>
<td>Production Cost (IDR)</td>
<td>18,000</td>
<td>30,500</td>
</tr>
<tr>
<td>Sales Results (IDR)</td>
<td>20,000</td>
<td>45,600</td>
</tr>
<tr>
<td>Profit (IDR)</td>
<td>2,000</td>
<td>15,100</td>
</tr>
</tbody>
</table>

* Calculated based on the ratio of actual biomass increased 86 g (non-biofloc) and 196 g (biofloc C/N ratio of 15:1) during this study.  
* Calculated based on the formula (feed/day x 1.68).

**Discussion**

The growth of the fish cultivated by using biofloc with the application of molasses with a ratio of C/N 15:1 has better growth when compared to catfish cultivated without molasses treatment. This is thought to be due to the formation of good floc that can provide additional food for catfish. However, catfish farmed with molasses treatment with a C/N ratio of 20:1 have worse growth when compared to catfish without molasses treatment, this is suspected because floc growth is too high resulting in interference with the cultivation media used in the study. The guess that researchers can convey is that there is a good balance between C and N content in maintenance media so that floc can grow well. With good floc growth, it will produce good fish growth as well.

Based on the results of the study above, biofloc is formed after molasses and probiotics are introduced into the maintenance media. Biofloc that is formed is the result of probiotic ingredients and this material is very good and relatively ideal in catfish farming. The resulting biofloc media can also provide faster and healthier catfish (Clarias sp.) growth (Suparno et al., 2016). This study showed that the use of biofloc provides good benefits to catfish farming systems. Previous research also explained that the use of biofloc in aquaculture systems can provide benefits such as additional feed sources for fish, tackling aquaculture waste, and reducing nitrogen to improve water quality (Rangka and Gunarto, 2012).

The survival rate of the fish cultivated using biofloc was higher than fish cultivated without molasses treatment. This is thought to be due to the presence of biofloc which can improve the water quality during maintenance even though no water changes are made, this is very different when compared to catfish without treatment, where water quality deteriorates due to no water changes and biofloc treatment during maintenance. Catfish farmed with C/N of 15:1 and 20:1 molasses treatment show ideal conditions for catfish farming activities with a biofloc system, this is because this treatment can produce an optimal catfish life rate of 100%. This means that during the maintenance no catfish were found to have died.

Based on the study of Perez-Fuentes et al. (2016), the biofloc system can reduce the occurrence of disease in cultivated biota, due to an increase in the immune system of species in the cultivated biota. The study also showed that during the 30-day test period, no symptoms or diseases were found. Even the result is a survival rate of 90 to 100%. Generally, the survival rate of catfish farming ranges from 80.87 - 98.87% (Pratiwi et al., 2020). This value is a high percentage and is associated with air-breathing and catfish's relatively high tolerance to poor water quality conditions. This result is also in line with the research of Shoko et al. (2016), which obtained a result of 95.42% with a survival rate of 98.83%.

In addition to accelerating growth, biofloc plays an important role as an alternative natural feed. In this study, the same amount of feed given has shown different biomass of fish. The biomass of fish cultivated by a using biofloc system with molasses treatment with a C/N ratio of 15:1 is higher than fish cultivated without biofloc. This is because biofloc contains crude protein which reaches 48.53% (Hastuti and Subandiyono, 2014). The use of a biofloc system can provide good feed efficiency compared to those without a biofloc system. This system can produce lower feed conversion (Yusuf et al., 2015; Putra et al., 2017; Pratiwi et al., 2020). This is because, in addition to commercial feed, fish are also given floc feed containing plankton. This value is better when compared to fish-fed commercial feed without biofloc application (Jimoh et al., 2014). The nutritional quality of biofloc is at least suitable for herbivorous and omnivorous fish species. In this
scope, catfish is categorized as an omnivorous eating habit.

By using the biofloc method, catfish are produced more, healthier, and use less water, with nutrient absorption of 25% than catfish farming using conventional methods. It can be seen from the stocking capacity of catfish seedlings which is 20 times more than conventional (Suparno et al., 2016). Subsequently, studies were conducted by Sumardani et al., (2018) conveying scientific data that the use of biofloc technology in catfish farming can increase catfish weight in a faster time, save water, and increase the efficiency of feed use. The addition of molasses as a carbon source in aquaculture systems can increase the C/N ratio of water. It will further reduce inorganic nitrogen in waters through increased growth of heterotrophic bacteria, where heterotrophic bacteria will form floc that can be consumed by fish as feed. Our study showed that the best C/N Ratio of 15:1 was then the C/N Ratio of 10:1. Research by Hargreaves (2006) presents that C/N >10:1 in fish farming systems is the optimum ratio to increase biofloc production and minimize ammonia regeneration. Research by Minabi et al. (2020) suggests that biofloc volume increases from C/N of 11:1 to C/N of 23:1.

The cultivation of fish by using a biofloc system with a C/N ratio of 15:1 has shown higher profit compared to those without biofloc system. This is due to high biomass and high efficiency of feed. The biofloc system can produce more biomass of fish with less amount of feed used during the cultivation process. This result is supported by research reported by Rukman (2023), the advantage of the biofloc technique in the catfish (Clarias batrachus) farming business is greater than conventional. Biofloc technology was feasible and profitable for catfish (Heteropneustes fossilis), it was considerably superior to saving money with a maximum attractive rate of return (Shamsuddin et al., 2022).

To complement our discussion regarding the results of research that has been carried out and refer to some literature related to catfish (Clarias sp.) farming biofloc systems, water quality data as presented in Table 3 were obtained. The feasibility of water quality variables is the first step of aquaculture activities that will affect the survival of cultivated biota. Water quality is also one and three success factors in aquaculture besides seed quality and feed quality (Amelia, 2018).

Table 3. Water quality of catfish farming biofloc system

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>25-30</td>
</tr>
<tr>
<td>DO / Dissolved Oxygen (mg/L)</td>
<td>1,7</td>
</tr>
<tr>
<td>pH</td>
<td>6,5-8</td>
</tr>
<tr>
<td>TAN / Total Ammonia Nitrogen (mg/L)</td>
<td>&lt;4</td>
</tr>
<tr>
<td>NH₃ / Ammonia (mg/L)</td>
<td>&lt;0,01</td>
</tr>
<tr>
<td>NO₂⁻ / Nitrite (mg/L)</td>
<td>&lt;1</td>
</tr>
<tr>
<td>NO₃⁻ / Nitrate (mg/L)</td>
<td>0,16-1,65</td>
</tr>
<tr>
<td>Alkalinity (mg/L CaCO₃)</td>
<td>20-400</td>
</tr>
</tbody>
</table>

The treatment of biofloc techniques in fish rearing makes the water quality in the maintenance container unstable, one of which is changes in the acidity (pH) of pond water. Pond water conditions that do not meet the standards will be harmful to the growth and survival of catfish (Amelia, 2018). Pond water with a pH that is too acidic or alkaline can cause fish farming failure. Changes in pH tend to be significant in waters that have low alkalinity, while waters with high alkalinity tend to experience insignificant pH changes. In addition to pH, water temperature also affects the mortality rate of fish. Water has a dominant influence on feed consumption response. The natural role of water quality is very influential in catfish farming so when aquaculture takes place, monitoring of aquaculture pond water is important to continue to be carried out (Al Qalit et al., 2017).

Furthermore, DO is a limiting factor in the cultivation system. When DO is not kept at a fulfilling value, then the fish become stressed and cannot eat properly. Kordi and Tancung (2007) said that ammonia levels contained in waters are the result of fish metabolism in the form of solid and dissolved feces released through the anus, kidneys, and gill tissue. While TAN is toxic (ionized), ammonia (NH₃), non-toxic (ionized), and ammonium (NH₄⁺), the amount of toxic un-ionized ammonia is determined by measuring TAN to obtain a concentration (mg/L) that describes water conditions. Nitrite remodeling or nitrification process by nitrifying bacteria by oxidizing ammonia to nitrite and nitrate while nitrate remodeling or denitrification process by denitrifying bacteria by reducing nitrate to nitrite with low oxygen content. The source of TAN in fish farming comes from inedible feed and fish metabolic waste. The accumulation of feed residues and metabolic waste is mostly in the form of nitrogen. Ammonia is one of the most toxic nitrogen compounds (Zaidy, 2022). While in this biofloc system, three processes can be
done to control ammonia, namely through the use of phytoplankton, bacterial assimilation, and nitrification.

Conclusion
Catfish farmed with biofloc technology at a C/N ratio of 15:1 show the best results on their growth and survival rate. In addition, catfish farming with a biofloc C/N ratio of 15:1 has a better economic analysis when compared to conventional catfish farming. The use of biofloc could be a recommendation to be applied in the community, especially among catfish farmers.

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