Different addition of molasses on feed conversion ratio and water quality in catfish (Clarias sp.) rearing with biofloc-aquaponic system

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Abstract. Biofloc system can overcome the problem on intensive system aquaculture by convert nitrogenous waste into microbial mass that can consumed by fish. Moreover, aquaponics systems that culture fish and plants also able to increase crop yields and improve water quality at the same time. Combination from those two system could create synergism to maximize the effects from both system. This study aims to determine the effect of molasses addition on feed conversion ratio (FCR) and water quality (TAN, nitrite and nitrate) of catfish rearing by biofloc-aquaponic system. This experimental study was carried out for 30 days using a Completely Randomized Design (CRD) consisting of four treatments with five replications. Those four treatments are based on the difference in the amount of molasses added. Data were analyzed by analysis of variance (ANOVA) followed by Duncan multiple range test (DMRT). The results of this study indicate that the different addition of molasses is able to bring a positive effect on FCR and water quality in the catfish rearing using biofloc-aquaponic system with the lowest FCR obtained by P3 (1.33) and the lowest nitrogenous waste obtained by P2 but the FCR were not significantly different with P3.

1. Introduction

To balancing the supply and demand of fish product, fish farmers applied aquaculture intensive system. Although yield more fish, there are drawback of this system such as, accumulation of nitrogenous waste from fish excretion and uneaten feed [1]. Poor water quality lead to poor feed utilization of fish [2]. High water exchange rate could overcome the poor water quality, but it costly.
and didn’t sustainable because it’s drain high volume of water that rich on nitrogenous waste on the water body [3].

One alternative to overcome those problems is aquaponic system and biofloc system. Biofloc is a fish culture system that maintains heterotroph bacteria to utilize ammonia and additional carbon source to produce microbial protein [2]. Bacteria ability to utilize ammonia and additional carbon source could reduce water exchange rate [4] and nitrogen content that drains to water body [3]. Bacterial flocs that consumed by fish not only increase feed efficiency rate, but also reduce feed conversion ratio [5]. While aquaponics is a system which combine hydroponic system with aquaculture as a nutrient source [6]. Nitrogen rich wastewater generated by aquaculture absorbed by plants on hydroponic system via their roots [7].

Biofloc and aquaponic system have their own advantages on fish growth, plants growth and water quality. Combination from those two system could create synergism to maximize the effects from both system. Recent study showed that combination from two system eliminates frequent water exchange and additional biofilter like conventional aquaponics system [7]. Furthermore, application of biofloc-aquaponic system could improve fish and lettuce productivity also reduce nitrogenous waste on water [3].

Until this moment, there is no study about *Clarias* catfish rearing in a bioflos system in association with aquaponic system and water spinach (*Ipomea aquatica*). This study aims to determine the effect of molasses addition on feed conversion ratio (FCR) and water quality of catfish (*Clarias* sp.) rearing by a biofloc-aquaponic system.

2. Materials and methods

2.1. Experimental design

This study applied completely randomized design with four treatments and five replications, as mentioned below:

a. P0 : control (without molasses).

b. P1 : biofloc-aquaponic system with molasses addition based on C:N ratio 10.

c. P2 : biofloc-aquaponic system with molasses addition based on C:N ratio 15.

d. P3 : biofloc-aquaponic system with molasses addition based on C:N ratio 20.

Addition of molasses based on carbon and nitrogen ratio on each treatment. Addition of molasses based on method from da Rocha [8], hence the amount of molasses also changed weekly according to fish weight and amount of protein consumed by catfish.

Biofloc-aquaponic system in this study is a combination of biofloc system and aquaponic system. The system consist of 25 liter plastic tank, filter tank, and plastic gutter located above the plastic tank. PVC pipe were used to connect the system. A submerged pump in filter tank promoted the flow of water from the filter tank to the gutter and fish tank. Continuous aeration was supplied by aerator to keep the oxygen content and prevent biofloc settling.

2.2. Animal and System Preparation

Preparation of biofloc was done through the addition of molasses based on the calculation, 1 mL.L⁻¹ probiotic [9] and 120 mg.L⁻¹ Ca(OH)₂ as a pH buffer [10] for one week until the water turned brownish and tiny clumps were formed which indicated that the bioflocs started being formed [11]. Water spinach (*Ipomea aquatica*) plantlets arranged in plastic gutter with rockwool substrate. *I. aquatic* stocked with 30 plants on each treatment based on Fitriani et al [12] the initial average weight of *I. aquatic* was 2.14 g and initial average length was 12.4 cm.

The initial average length of catfish was 15.18 cm, while the initial average weight of catfish was 36.86 g. The fish were reared in plastic tank filled with 20 liter freshwater. Each tank filled with 10 catfish with 18.43 g.L⁻¹ stocking density [13]. All treatment receives water to compensate for water loss due to evaporation. The fish were fed daily at 3% body weight with PF-1000 pellet that contain 41 % crude protein. The addition of molasses as carbon source was performed once every three days at two hours after feeding in the morning [5]. This catfish rearing was carried out for 30 days.
2.3. Parameter observed
Parameter observed during catfish culture included feed conversion ratio (FCR) and it is water quality (TAN, nitrite, nitrate). FCR was calculated using this formula [11]:

\[
FCR = \frac{F}{(W_t + W_d) - W_0}
\]

While the side parameters survival rate (SR), dissolved oxygen, pH, temperature, orthophosphate, and plant growth. Survival rate was calculated this formula [14]:

\[
SR(\%) = \frac{\text{final number of fish}}{\text{initial number of fish}} \times 100
\]

2.4. Data analysis
One Way ANOVA (Analysis of Variance) was carried out to analyze the data. If significant differences were observed (P<0.05), then followed by Duncan’s multiple range test to identify differences among treatments. All analysis was performed using IBM SPSS 21.

3. Results and discussion
3.1. Results

Table 1. Catfish Feed Conversion Ratio

| Treatment | Feed Conversion Ratio ± SD |
|-----------|-----------------------------|
| P0        | 1.51 ± 0.04                 |
| P1        | 1.58 ± 0.08                 |
| P2        | 1.40 ± 0.11                 |
| P3        | 1.33 ± 0.09                 |

Note: Different superscript indicate significant difference (P<0.05).

Table 2. TAN concentration during research

| Treatment | Day 10 | Day 20 | Day 30 |
|-----------|--------|--------|--------|
| P0        | 0.13 ± 0.01 | 0.04 ± 0.05 | 1.66 ± 0.04 |
| P1        | 1.62 ± 0.03 | 2.24 ± 0.01 | 2.04 ± 0.05 |
| P2        | 1.61 ± 0.04 | 0.54 ± 0.04 | 0.74 ± 0.05 |
| P3        | 1.53 ± 0.05 | 3.12 ± 0.08 | 3.59 ± 0.06 |

Note: Different superscript indicate significant difference (P<0.05).

Table 3. Nitrite concentration during research

| Treatment | Day 10 | Day 20 | Day 30 |
|-----------|--------|--------|--------|
| P0        | 0.17 ± 0.06 | 0.09 ± 0.02 | 0.18 ± 0.02 |
| P1        | 0.02 ± 0.005 | 0.10 ± 0.01 | 0.06 ± 0.01 |
| P2        | 0.13 ± 0.04 | 0.32 ± 0.11 | 0.36 ± 0.03 |
| P3        | 0.05 ± 0.01 | 0.42 ± 0.02 | 0.06 ± 0.03 |

Note: Different superscript indicate significant difference (P<0.05).
Table 4. Nitrate concentration during research

| Treatment | Nitrate (mg.L⁻¹) ± SD |
|-----------|-----------------------|
|           | Day 10                | Day 20                | Day 30                |
| P0        | 26ᵇ ± 1.10           | 17ᵇ ± 6.42           | 17ᵇ ± 6.42           |
| P1        | 9ᵃ ± 2.24            | 14ᵇ ± 1.10           | 14ᵇ ± 1.10           |
| P2        | 43ᵇ ± 3.72           | 46ᵇ ± 3.58           | 26ᵃ ± 3.58           |
| P3        | 25ᵇ ± 2.86           | 42ᵃ ± 2.73           | 24ᵃ ± 2.73           |

Note: Different superscript indicate significant difference (P<0.05).

Table 5. Side parameter water quality

| Parameter       | P0    | P1    | P2    | P3    | Optimal value [15] |
|-----------------|-------|-------|-------|-------|-------------------|
| DO (mg.L⁻¹)     | 5.11 ± 8.11 | 3 – 4.96 | 4.56 – 6.78 | 4.15 – 6.60 | 5 |
| pH              | 7.2 – 8.5  | 7.2 – 8.2 | 72 – 8.0 | 7.1 – 8.0 | 7 – 8.5 |
| Temp (°C)       | 24 – 30   | 24 – 32 | 24 – 30 | 24 – 30 | 20 – 30 |
| PO₄³⁻ (mg.L⁻¹) | 0.51 – 1.04 | 1.46 – 1.63 | 0.54 – 1.34 | 0.73 – 1.91 | 0.01 – 3 |

Table 6. Catfish survival rate

| Treatment | Survival Rate (%) |
|-----------|-------------------|
| P0        | 78                |
| P1        | 84                |
| P2        | 92                |
| P3        | 94                |

Table 7. Plant growth data

| Treatment | Stem Length (cm) | Leaves Number | Plant Weight (g) |
|-----------|------------------|---------------|------------------|
|           | Initial | Final | Initial | Final | Initial | Final |
| P0        | 12.4    | 80.72  | 5      | 21     | 2.14    | 824.87  |
| P1        | 12.4    | 57.54  | 5      | 14     | 2.14    | 442.50  |
| P2        | 12.4    | 42.14  | 5      | 19     | 2.14    | 747.14  |
| P3        | 12.4    | 59.70  | 5      | 13     | 2.14    | 886.75  |

3.2. Discussion

The addition of molasses at different concentration on feed conversion ratio of catfish rearing in the biofloc-aquaponic system showed a statistically different result (P<0.05). The lowest feed conversion obtained by P3 treatment, but it shows no significant difference with P2 treatment. Water quality parameters such as total ammonia nitrogen (TAN), nitrite and nitrate showed statistically different result (P<0.05) every week and showed by table 2, 3 and 4.

The lowest feed conversion ratio in this study obtained by treatment P3. This finding was in accordance with the research conducted by [3] and [7] where the biofloc-aquaponic system has the lowest feed conversion. Increased biofloc consumption of fish could decrease feed conversion on treatment P2 and P3 [3]. Furthermore, biofloc consumption by fish also increase amylase and lipase activity on fish gut, so the lowest feed conversion obtained on P3 [16].

Better water quality gives positive effect on FCR [17]. Low FCR on P0 compared with P1, likely owing to better average dissolved oxygen content on P0 (6.9 mg.L⁻¹), while the average oxygen content on P1 just 3.7 mg.L⁻¹. Low dissolved oxygen on P1 could break biofloc structure and makes fish harder to consume it [18]. Additionally, total ammonia nitrogen on P0 was lower (0.6 mg.L⁻¹), while on P1 reach 1.96 mg.L⁻¹. While applied biofloc-aquaponic system in this study give lower FCR than control treatment, feed conversion value from this study were higher than other biofloc research’s. Heavier fish (36.86 g) used in this study contribute to higher feed conversion. Because
bigger and older fish were less efficient on utilize the feed and led to slower growth rate and higher feed conversion [17].

TAN concentration on this study was higher than [7] study, where the lowest concentration of TAN obtained on biofloc-aquaponic system. But TAN concentration on P1 until P3 never exceed 4 mg.L⁻¹, which is the maximum TAN concentration that can be tolerated by fish [19]. The TAN concentration on P3 increased gradually from day 0 until day 30. Increased feed input and fast growth rate of catfish contribute to higher nitrogenous waste excreted by fish [20]. However, TAN concentration on control treatment was lower than other treatments on day 10. But, there was up and down of TAN concentration on day 20 until day 30. Increased TAN on day 30 indicate that there were insufficient bacteria population available to convert the inorganic nitrogen into microbial mass [11].

Compared to other nitrogenous wastes, nitrite was barely detectable because the nitrification bacteria rapidly convert it to nitrate [21]. During fish rearing, nitrite concentration never exceed 2 mg.L⁻¹. So, the nitrite concentration still safe for fish, because it’s never exceeds 2 mg.L⁻¹ [22]. Nitrate concentration on treatment with molasses addition increased gradually from day 10 to day 20 and then decreased on day 30. Nitrate fluctuation caused by nitrification process on this system [23]. Nitrate accumulation likely due to the rapid growth of catfish and augment of feeding [20]. Because heavier fish produce more nitrogenous waste. But, denitrification processes that convert nitrate to N₂O/N₂ and aborbing nitrate by plants could decrease nitrate concentration [24].

Catfish that reared on control treatment showed diverse growth rate, which later increasing cannibalism and aggressive behavior towards smaller and weaker fish. Research article also showed same result on control treatment [9]. Rearing catfish on high turbidity water like biofloc system could reduce cannibalism because of reduced visibility [25]. Higher survival rate on P3 and P2 show that applied biofloc-aquaponic system could increase fish durability against harsh environment by producing more antioxidant and improving immune system [26]. Eventhough TAN concentration on P3 was higher than other treatments, but the survival rate were the higher. The highest molasses addition on P3 led to increased biofloc formation, while the catfish growth also increased. Increased consumption of biofloc contributes to improved immune system [26,27]. Bigger fish used in this study also has more endurance in harsh condition like high TAN concentration [28].

The orthophosphate concentration in all treatments increased during study. Continuous feed input, molasses addition, and accumulation of fish feces increase the orthophosphate concentration quickly [29]. Mineralization process and Bacillus decomposition also increase orthophosphate availability on water [30]. The highest orthophosphate concentration obtained on P3 with 1.909 mg.L⁻¹. High orthophosphate concentration related to increased plants growth as stated by [30]. That was proven by the highest water spinach yield obtained by P3 as much as 4433.74 grams.

4. Conclusion
Molasses addition give positive effect on FCR and water quality in catfish rearing with biofloc-aquaponic system. While the best FCR and water quality obtained by treatment P2 with molasses addition based on C:N ratio 15:1.

5. References
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