Effectiveness of striped catfish (*Pangasianodon hypophthalmus*) cultivation in aquaponic system with three different plant against ammonia (NH$_3$), nitrite (NO$_2$), and nitrate (NO$_3$)

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Abstract. The purpose of this study was to determine which plants are effective and can affect the concentration of ammonia, nitrite, and nitrate in the cultivation of Striped Catfish in aquaponics systems. This research was conducted from 22 February to 23 March 2021 at the Faculty of Fisheries and Marine, Airlangga University, Surabaya using a Completely Randomized Design (CRD) research method with 4 treatments and 5 replications. The three plants used were kailan, lettuce, and pakcoy. One-way analysis (ANOVA) was used to compare the control group with the treatment at a significant level of P<0.05. Multiple Range Test (DUNCAN) was used to identify significant differences between the treatments. The results showed that the lowest concentrations of ammonia, nitrite, and nitrate were obtained by the treatment using lettuce plants with values ranging from 0.039-0.723 mg/L, 0.207-0.370 mg/L, and 6.181-9.923 mg/L, respectively.

1. Introduction

Striped catfish (*Pangasianodon hypophthalmus*) is one of the consumption fish from the freshwater sector commodity which has a savory meat taste and contains high protein, so that it is in great demand by consumers and increases market demand. There are many obstacles to meet market demand, including limited water, limited area, and pollution to the environment [1]. To overcome these problems, a technology called an aquaponics system is applied.

The aquaponics system is a combination of an aquaculture system and a hydroponic system. In the aquaculture system, it will produce feces, urine, and leftover feed which will accumulate into aquaculture waste containing substances that are harmful to the fish being cultivated, but can be utilized by the hydroponic system for growth, so it is hoped that the water quality will be good because these substances have been utilized harmful by plants in hydroponic systems [2].

In the hydroponic system, kailan, lettuce, and pakcoy are used. Kailan plants were chosen because Ratnawati *et al.* [3] said that nitrogen has an important role in the formation of fresh green leaves and contains sufficient fiber. The N element is very important for the formation of protein, stimulates vegetative growth and increases fruit yields [4]. Lettuce is used because it is a plant that has a taproot that is accompanied by horizontal growth and thickening of lateral roots. These lateral roots function...
to absorb some water and nutrients [5]. Pakcoy plants were also chosen because according to Pracaya [6] pakcoy requires more nitrogen nutrients for growth or are often called heavy feeders. It was also said by Damanik et al. [7] that pakcoy is effective in absorbing nitrate, so that the water in the aquaponic system that uses this plant has good quality.

2. Materials and methods

2.1. Time and Place
This research was conducted on February 22 - March 23, 2021 at the Anatomy and Aquaculture Laboratory and at the Chemistry and Analysis Laboratory, Faculty of Fisheries and Marine, Universitas Airlangga, Surabaya, East Java.

2.2. Experimental Design
This study was conducted for 28 days using a Completely Randomized Design (CRD). This study used 4 treatments, namely P0, P1, P2, and P3 with 5 replications. Where P0 is the control treatment or cultivation of Striped Catfish without plants, P1 is the cultivation of Striped Catfish in aquaponics system using kailan plants, P2 is the cultivation of Striped Catfish in aquaponics system using lettuce plants, and P3 is the cultivation of Striped Catfish with aquaponic system using pakcoy plants. The materials used in this study were the seeds of striped catfish (Pangasianodon hypophthalmus) with a size of 8-12 cm as many as 300 fish which were placed 18 fish in each aquarium as research objects, and 25 of each plant based on each treatment with aged 14 days as research objects. Feed is given at a dose of 5% of the fish body biomass. Feeding is given every day in the morning and evening. Maintenance of this fish in an aquaponic system was carried out for 28 days.

2.3. Ammonia Concentration Measurement
Ammonia concentration measurements were carried out every seven days for four times using a spectrophotometer. Ammonia concentration measurements were carried out based on Indonesia National Standard [8] with the phenate method using a wavelength of 640 nm.

2.4. Nitrite Concentration Measurement
Measurement of nitrite concentration was carried out once every seven days for four times using a spectrophotometer. Measurement of nitrite concentration was carried out based on Indonesia National Standard [9] using a wavelength of 543 nm.

2.5. Nitrate Concentration Measurement
Measurement of nitrate concentration was carried out once every seven days for four times using a spectrophotometer. Measurement of nitrate concentration was carried out based on Lenore et al. [10] using wavelengths of 220 nm and 275 nm.

2.6. Supporting Parameters
Supporting parameters for water quality in the form of temperature, DO and pH were carried out twice a day every morning and evening.

2.7. Data Analysis
The data are expressed as the mean standard deviation. One-way analysis of variance (ANOVA) was applied to compare the control and treatment groups at a significant level of P<0.05. Duncan's Range Test was used to identify significant differences in the concentrations of ammonia, nitrite, and nitrate on ANOVA.
3. Result and Discussion

3.1. Ammonia

Table 1. Average concentration of ammonia during the study

| Treatment | Ammonia Concentration (mg/L) ± SD |
|-----------|----------------------------------|
|           | Day 0 | Day 7 | Day 14 | Day 21 | Day 28 |
| P0        | 0.233\(^a\) ± 0.072 | 0.168\(^b\) ± 0.053 | 0.278\(^c\) ± 0.075 | 0.462\(^b\) ± 0.260 | 1.072\(^b\) ± 0.089 |
| P1        | 0.672\(^b\) ± 0.068 | 0.026\(^a\) ± 0.003 | 0.138\(^ab\) ± 0.008 | 0.324\(^ab\) ± 0.114 | 1.031\(^b\) ± 0.113 |
| P2        | 0.637\(^b\) ± 0.091 | 0.039\(^a\) ± 0.017 | 0.106\(^a\) ± 0.014 | 0.185\(^a\) ± 0.054 | 0.723\(^a\) ± 0.191 |
| P3        | 0.315\(^a\) ± 0.014 | 0.034\(^a\) ± 0.009 | 0.163\(^b\) ± 0.008 | 0.252\(^a\) ± 0.060 | 0.743\(^a\) ± 0.135 |

During the study, ammonia levels were observed five times every seven days. The value of ammonia content during the study based on the results ranged from 0.207-1.072 mg/L in Table 1. The results of statistical tests on day 0 showed that there was a significant difference (P<0.05) for each treatment and it was known that P2 was not significantly different from P1 but significantly different from P0 and P3. The results of the statistical tests on day 7 showed that there was a significant difference (P<0.05) on each treatment and it was known that P2 was not significantly different from P1 and P3 but significantly different from P0. The results of statistical tests on day 14 showed that there was a significant difference (P<0.05) on each treatment and it was known that P2 was not significantly different from P1 but significantly different from P3 and P0. The results of statistical tests on day 21 showed that there was no significant difference (P>0.05) on each treatment and it was known that P2 was not significantly different from P3 and P1 but significantly different from P0. The results of statistical tests on day 28 showed that there was a significant difference (P<0.05) on each treatment and it was known that P2 was not significantly different from P3 but significantly different from P1 and P0.

3.2. Nitrite

Table 2. Average concentration of nitrite during the study

| Treatment | Nitrite Concentration (mg/L) ± SD |
|-----------|----------------------------------|
|           | Day 0 | Day 7 | Day 14 | Day 21 | Day 28 |
| P0        | 0.637\(^b\) ± 0.081 | 0.567\(^c\) ± 0.047 | 0.477\(^b\) ± 0.102 | 0.421\(^b\) ± 0.132 | 0.369\(^b\) ± 0.169 |
| P1        | 0.403\(^a\) ± 0.058 | 0.361\(^a\) ± 0.020 | 0.331\(^a\) ± 0.043 | 0.307\(^a\) ± 0.041 | 0.265\(^ab\) ± 0.078 |
| P2        | 0.370\(^a\) ± 0.119 | 0.266\(^a\) ± 0.067 | 0.255\(^a\) ± 0.061 | 0.234\(^a\) ± 0.041 | 0.207\(^a\) ± 0.006 |
| P3        | 0.397\(^a\) ± 0.086 | 0.338\(^b\) ± 0.032 | 0.301\(^a\) ± 0.025 | 0.277\(^a\) ± 0.048 | 0.256\(^ab\) ± 0.072 |

During the study, the nitrite levels were observed five times every seven days. The value of ammonia content during the study based on the results ranged from 0.207-0.637 mg/L in Table 2. The results of statistical tests on day 0 showed a significant difference (P<0.05) on each treatment and it was known that P2 was not significantly different with P3 and P1, but significantly different from P0. The results of statistical tests on day 7 showed that there was a significant difference (P<0.05) on each treatment
and it was known that P2 was significantly different from all treatments, namely P3, P1, and P0. The results of statistical tests on day 14 showed that there was a significant difference (P<0.05) on each treatment and it was known that P2 was not significantly different from P3 and P1, but significantly different from P0. The results of the statistical test on day 21 showed that there was a significant difference (P<0.05) on each treatment and it was known that P2 was not significantly different from P3 and P1, but significantly different from P0. The results of statistical tests on day 28 showed that there was no significant difference (P>0.05) on each treatment and it was known that P2 was not significantly different from P3 and P1, but significantly different from P0.

3.3. Nitrate

Table 3. Average concentration of nitrate during the study

| Treatment | Nitrate Concentration (mg/L) ± SD |
|-----------|----------------------------------|
|           | Day 0   | Day 7   | Day 14  | Day 21  | Day 28  |
| P0        | 7.556b ± 0.572 | 11.452d ± 0.579 | 12.718d ± 0.205 | 13.148d ± 0.240 | 13.577d ± 0.043 |
| P1        | 7.287b ± 0.288 | 10.877c ± 0.158 | 12.487c ± 0.149 | 12.819c ± 0.066 | 13.377c ± 0.146 |
| P2        | 6.180a ± 0.443 | 6.918a ± 0.103 | 7.186a ± 0.113 | 8.025a ± 0.106 | 9.923a ± 0.111 |
| P3        | 7.083b ± 0.171 | 8.944b ± 0.142 | 10.115b ± 0.097 | 12.090b ± 0.055 | 12.895b ± 0.020 |

During the study, the nitrate levels were observed five times every seven days. The value of nitrate content during the study based on the results ranged from 6.181-13.578 mg/L in Table 3. The results of statistical tests on day 0 showed that there was a significant difference (P<0.05) for each treatment and it was known that P2 was significantly different from all treatments are P3, P1, and P0. The results of the statistical test on day 7 showed that there was a significant difference (P<0.05) between each treatment and it was known that P2 was significantly different from all treatments. The results of statistical tests on day 14 showed that there was a significant difference (P<0.05) between each treatment and it was known that P2 was significantly different from all treatments. The results of statistical tests on day 21 showed that there was a significant difference (P<0.05) between each treatment and it was known that P2 was significantly different from all treatments. The results of statistical tests on day 28 showed that there was a significant difference (P<0.05) between each treatment and it was known that P2 was significantly different from all treatments.

3.4. Water quality

Based on the results of the average water quality parameters for each treatment in the catfish aquaponic system, the water temperature ranged from 27.9-29.20°C, pH between 7.5-7.8 and DO ranged from 4.90-5.21 mg/l.

Table 4. Average of water quality during the study

| Parameters          | P0  | P1  | P2  | P3  |
|---------------------|-----|-----|-----|-----|
| Temperature (°C)    | 29.2| 27.2| 28.4| 28.3|
| pH                  | 7.55| 7.8 | 7.6 | 7.7 |
| Dissolved Oxygen (DO) (mg/l) | 4.90| 4.99| 5.21| 5.04|
3.5. Discussion
Ammonia in aquaculture waters comes from uneaten feed residues, the results of feed metabolism and also from the decomposition of dead organisms. Within certain limits, ammonia can be toxic to farmed fish. Ammonia toxicity increases with high temperature and pH and low dissolved oxygen content [11]. Ammonia in the water will be converted into nitrate through the nitrification process.

Nitrite is one of the compounds resulting from the nitrification process in the first stage of ammonia oxidation. Nitrite is also one of the compounds that can be toxic to cultured fish because if the nitrite level exceeds the normal limit it can cause a decrease in the ability of fish to bind oxygen in the blood which can eventually have an impact on death [12].

Nitrate is one of the safest inorganic compounds for aquatic organisms when compared to ammonia and nitrite. However, if it exceeds the normal limit, it can also cause death because increased levels of nitrate in the water can cause algae blooms. Blooming algae that occur in waters can cause a decrease in dissolved oxygen levels in water [13]. Nitrates are compounds resulting from the second stage of the nitrification process of nitrite oxidation.

The results of observations of concentrations of ammonia, nitrite, and nitrate in aquaculture water during the study showed fluctuations, but the lowest concentrations of ammonia, nitrite, and nitrate belonged to the P2 treatment, which was carried out by the aquaponic system of striped catfish rearing using lettuce plants. The lowest ammonia concentration at the end of the study was P2 with a value of 0.723 mg/L. The lowest nitrite concentration at the end of the study was P2 with a value of 0.207 mg/L. The lowest nitrate concentration at the end of the study was P2 with a value of 9.923 mg/L.

The low concentration of ammonia, nitrite and nitrate in aquaculture waters can be an indication that the quality of aquaculture water is in good condition, so it can support the work of bacteria in carrying out nitrification tasks to oxidize hazardous materials such as ammonia to nitrite. then nitrite to nitrate which will later be absorbed by plant roots, which is useful for growth. In addition, temperature. DO and pH also affect the concentration of ammonia, nitrite, and nitrate in aquaculture water. Irianto [14] said that if the water temperature is high, it will cause stress for fish, whereas if the water temperature is low, it can cause fish to become more susceptible to pathogen infection. High temperatures are usually followed by low oxygen levels (DO) because the fish's body metabolism will require more oxygen. while Effendi [13] said that low oxygen levels are not enough to remodel ammonia, so that under anaerobic conditions ammonia is toxic to fish. The pH of the waters is also known to affect the toxicity of a chemical compound in the water. namely ammonia. As stated by Wahyuningsih and Gitarama [11] if the pH is high, non-ionized ammonia (NH3) will dominate, and ammonium (NH4) will dominate in waters when the pH is low. In addition to ammonia. Hetty et al. [15] also said that pH can affect the concentration of nitrate in water. the closer to the alkaline state, the nitrate concentration will tend to be higher. The growth and activity of ammonia-oxidizing bacteria is also influenced by pH [16].

4. Conclusion
Based on the results of the study, it can be concluded that the kailan, lettuce, and pakcoy plants have an effect on the absorption of ammonia, nitrite, and nitrate concentrations in the cultivation of striped catfish (*Pangasianodon hypophthalmus*) aquaponic systems. Plants that are effective in absorbing the content of ammonia, nitrite, and nitrate in the cultivation of striped catfish in aquaponics system from day 0 to day 28 are lettuce plants with an average value of ammonia ranging from 0.039 – 0.723 mg/L. the average the value of the nitrite concentration ranged from 0.207-0.370 mg/L and the average value of the nitrate concentration ranged from 6.181 to 9.923 mg/L.

5. References
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