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Effect of the Addition of Shrimp Head Flour in Feed on Increasing the Color Brightness of Peacock Cichlid (*Aulonocara* sp.).

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KEYWORDS
shrimp head flour; peacock cichlid; feed; astaxanthin; color; growth

ABSTRACT
This research aims to determine the optimal dosage of shrimp head flour addition in feed to increase the color brightness of peacock cichlid strain dragon blood. This research was carried out in Dewasari Village, Cijeungjing District, Ciamis Regency with a research period from March to May 2024. The research method was a completely randomized design (CRD) experiment with 4 treatments which included (A) 0% control, (B) 5%, (C) 10%, and (D) 15%. The research was conducted for 50 days and observations were made every 10 days on the color of fish kept with Toca Color Finder. The results showed that the addition of shrimp head flour to the feed could increase the color brightness of peacock cichlid with significantly different results from the control treatment but not significantly different between the treatment with the addition of shrimp head flour. The highest color increase was obtained in treatment C with the addition of 10% shrimp head flour with an average score of 4.53 and a color improvement value of 2.2 scores and color change values. There was no significant difference between all treatments for absolute length growth (L) and absolute weight growth (W).

Introduction

The development of Indonesian ornamental fish has become more and more rapid with the development of ornamental fish farming communities, thus providing opportunities for ornamental fish farmers and entrepreneurs to increase their income (Afnan et al., 2019). According to the Central Statistics Agency (2021), fish production from the ornamental fish farming sector in Indonesia in 2021 has reached 1,297,021 fish.

Peacock cichlid (*Aulonocara* sp.) is a cichlid endemic to Lake Malawi located in East Africa (Konings, 1989). Malawi cichlid fish is a freshwater fish with diverse and striking colors that make it very popular among ornamental fish hobbyists because it is easy to maintain and breed in captivity (Konings, 1989). Peacock cichlid is an easy fish to breed so it has been widely cultivated and developed to obtain a variety with more varied colors. The peacock cichlid strain dragon blood is a hybrid peacock cichlid strain that has an orange body color that tends to be reddish (Glaser, 2021).

The color of ornamental fish is one of the important criteria in ornamental fish because the brighter the color of the ornamental fish, the higher the value of the fish (N. Fitriana et al., 2013). According to (Lesmana, 2002), the color change in fish is caused by a change in the number of chromatophore pigment cells in the skin layer on fish scales both inside and outside the scales of the fish body, the more denser of the pigment cells in the fish body, the intensity and brightness of the color will also increase. Chromatophore cells can be classified into 5 basic color categories, namely black (melanophore), yellow (xanthophore), red or orange (erythrophore), shiny reflection (iridophore) and white (leukophore) (Anderson, 2001). The brightness of fish color can be increased through the addition of pigment-containing materials in the feed so that it can increase the concentration and distribution of chromatophores in fish skin tissue (Dahlia, 2014).

Carotenoids are fat-soluble pigments and have yellow, orange and red colors (Bovšková et al., 2014). Carotenoids are the main components that make up the red and yellow colors in fish (Subamia et al., 2010). Fish cannot synthesize carotenoids and must obtain them from food sources which are then stored in the body's tissues either without alteration or with some metabolic alteration (Lovell, 1992). The body of fish cannot synthesize red, orange, and yellow colors so the formation of color in the body of fish depends on the carotenoids contained in the feed (Sholichin et al., 2012). Astaxanthin is a naturally occurring carotenoid in the group of fat-soluble xantofphiles and is included as a powerful antioxidant that can be synthesized by plants and some types of algae (Nurdianti et al., 2017). Astaxanthin is the most effective type of carotenoid pigment for improving coloration in fish (Meiyana & Minjoyo, 2011). According to (Agustini, 2002), astaxanthin is a basic color that can be absorbed and stored as a red pigment.

Aquatic animals such as crabs, lobsters and shrimp can accumulate astaxanthin as the main carotenoid in their bodies by eating live foods rich in carotenoids (Wathne et al., 1998). Parts of shrimp that become by-products such as shrimp heads, shells and tails are one of the most frequently used sources of astaxanthin (Nirmal et al., 2020). One form of its use is shrimp head flour which contains ingredients such as chitin, carotenoids, proteins, and minerals (Damuringrum, 2002). Shrimp head flour has 12.2 mg/kg astaxanthin and 47.4 mg/kg cantaxantin content (Hertrampf & Piedad-Pascual, 2012). Shrimp head is one of the natural sources of carotenoids, especially astaxanthin, and is often added to ornamental fish feed to increase color brightness (Sutihat 2003). In addition to astaxanthin content, shrimp head flour also has a nutritional content which includes protein 31.41%, fat 6.62%, energy 3.75kcal/g and crude fiber 5.59% (Wahyudi et al., 2023).

Based on the background, the problem that can be identified is how the addition of shrimp head flour to the feed will affect the increase in color brightness in peacock cichlid (*Aulonocara* sp.) and what is the amount of dosage to increase the brightness of the color to the maximum. This research aims to analyze and determine the effect of the addition of shrimp head flour in feed as a source of carotenoid astaxanthin on the increase in the color brightness of peacock cichlid (*Aulonocara* sp.). The results of this research are expected to provide information for researchers, cultivators and hobbyists regarding the effect of adding shrimp head flour to feed to increase the color brightness of peacock cichlid (*Aulonocara* sp.) especially in the dragon blood strain with a dose that can increase the brightness of the color to the maximum.

Research Methods

This research was carried out in Dewasari Village, Cijeungjing District, Ciamis Regency. The research was carried out for 50 days starting from March to May 2024. The tools used in this research are an aquarium with a size of 35 x 30 x 25 cm, Resun LP-20 aerator, aerator hose, Amara AA-933 sponge filter, Rosston RSK-25 heater, grinder, pelleting machine, ATC-190012 digital pH meter, DO-9100 digital DO meter and thermometer, SF-400 digital scale, Toca Color Finder (TCF), strainer, syphon hose, ruler, millimeter block, *mobile phone*, and stationery. The materials used in this research were 80 peacock cichlid strain dragon blood with an average length of 5,92±0,02 cm and a weight of 3,56±0,21grams, PF 1000 commercial pellets with 39–41% protein, artificial feed as treatment feed on fish made from commercial pellets and shrimp head flour through the repelling method, shrimp head flour, and Boster Progol pellet binder.

Research Procedure

The research was conducted on 80 peacock cichlid strain dragon blood which were kept in 16 aquariums with a size of 35 x 25 x 30 cm equipped with an aerator connected to a sponge filter and heater. Fish are kept at a stocking density of 4.2 liters/fish or 5 fish per aquarium based on the research of (de Souza Silva et al., 2021). Fish rearing is carried out for 50 days with feeding rate of 2 times a day as much as 5% of the total biomass of the fish. Feeding was carried out according to each treatment for 40 days, then control feed was carried out on all treatments for the last 10 days to observe the effect of stopping the feed with additional carotenoids on the brightness of fish color. The feed used is an artificial feed made from commercial pellets and shrimp head flour through the repelleting method by grinding commercial pellets using a grinder, then mixing pellets in the form of flour with shrimp head flour and pellet binder which are then molded according to the required size.

Observations are made every 10 days on fish and water quality. Observation of changes in color brightness was done using Toca Color Finder (TCF) to observe the color code on the body of the fish. Observation of the growth of length and weight was carried out by measuring the length of the fish and weighing the weight of the fish biomass during the study. Measurement of water quality parameters were carried out on temperature, pH, and dissolved oxygen (DO). The data obtained from the observation is recorded and further processed in the calculation of data analysis.

Research Methods

The research method used in this research is experimental using a completely randomized design (CRD) consisting of 4 treatments and 4 replication.

Treatment A : Feeding without additional shrimp head flour (control).
Treatment B : Feeding with an additional 5% shrimp head meal.
Treatment C : Feeding with an additional 10% shrimp head meal.
Treatment D : Feeding with an additional 15% shrimp head meal.

Observation Parameters

Rate of Change in Brightness of Fish Color

Observation on the change in the level of color brightness is carried out every 10 days for 50 days. Observations were made by 3 panelists who were not color blind to avoid bias. The observed parameter was the color brightness value on the body of the peacock cichlid strain dragon blood using a scale based on the color code on the TCF which had been given a score of one to seven. The results obtained from the observation of the color change rate are data on the value of the increasing color brightness which is then analyzed descriptively.

Absolute Length Growth

Observation of the absolute length growth was carried out by calculating the length of the fish using a ruler at the beginning and end of the study. Absolute length growth is calculated using the following formula of (Effendie, 1997):

$$L = Lt - Lo$$

Information:

L = Growth of absolute length of fish (cm)
Lt = Length of fish at the end of the research (cm)
Lo = Length of fish at the beginning of the research (cm)

Absolute Weight Growth

Observation of the absolute length growth was carried out by calculating the weight of fish biomass using scales at the beginning and end of the study. Absolute weight growth is calculated using the following formula of (Effendie, 1997):

$$H = Wt - Wo$$

Information:

H = Growth in absolute weight of fish (grams)
Wt = Weight of fish at the end of the research (grams)
Wo = Weight of fish at the beginning of the research (grams)

Water Quality Parameters

Observation of water quality parameters is carried out on temperature, dissolved oxygen (DO) and pH to maintain the water condition in the tank so that it is within the standard condition. Temperature parameters were observed using a thermometer, dissolved oxygen was observed using a DO meter and pH was observed using a pH meter.

Data Analysis

The data of color brightness change was analyzed descriptively and the color increase value was analyzed using the Kruskal-Wallis test, but if there was a difference between treatments, the Z test was carried out with a confidence level of 95%. The data on absolute length growth and absolute weight growth were analyzed using the analysis of variance (ANOVA) using F test with a confidence level of 95%. Water quality data was analyzed in a comparative descriptive manner.

Results and Discussions

Increased Brightness of Peacock Cichlid Color

The results of the research conducted for 50 days showed that the addition of shrimp head flour to the feed could significantly affect the color brightness of peacock cichlid strain dragon blood ($p < 0.05$) when compared to the control. The increase in color brightness in peacock cichlid is found in the body part. The treatment with the highest color brightness increase value was treatment C (10%) with an average score of 4.53 followed by treatment D (15%), B (5%), and A (Control). The following is a graph of the average increase in color brightness from the beginning to the end of the research based on the TCF score (Figure 1).

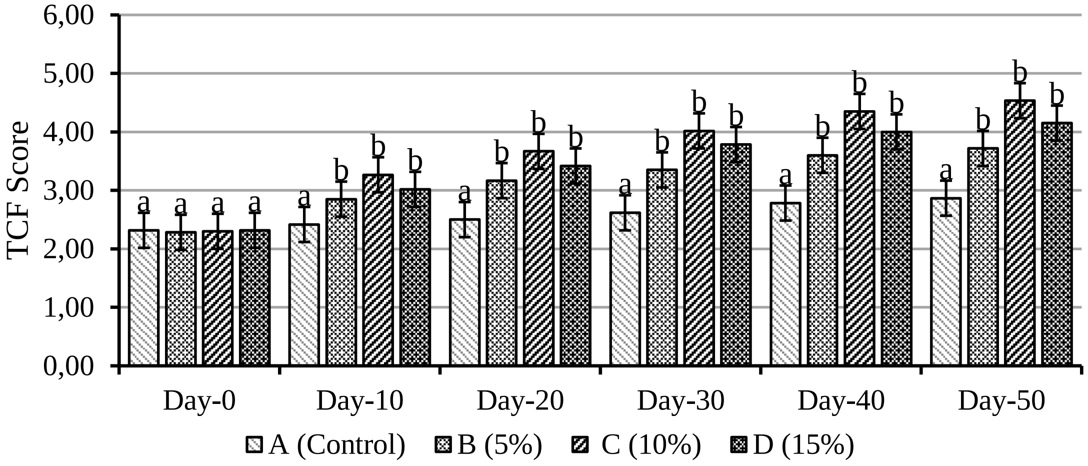

Figure 1. Average Chart of Changes in Color Value of Peacock Cichlid

Based on the graph of the average color brightness change, on day 0 of the rearing period, the color value of the peacock cichlid from all treatments ranged from 2.28 to 2.32. On the 10th day, an increase in color can be observed in all treatments with an average of 2.42 to 3.27. On the 20th day of the maintenance period, a significant increase in color values occurred in treatment B (5%) with an average score of 3.17, C (10%) with an average score of 3.67 and D (15%) with an average score of 3.42. The increase in the color value of treatment A (Control) was the lowest with an average score of 2.50 but showed a slight improvement. This can happen because the color of the fish is not only influenced by the pigment but can also be influenced by the age of the fish, the ripening of the color appearance in the fish and the quality of the water (Lagler et al., 1997).

On the 30th day, a significant increase in color values can still be observed in treatments B (5%), C (10%), and D (15%) but the increase in color in treatment B is lower when compared to treatments C and D without a significant difference. The increase in color values in treatment A (Control) has the lowest value when compared to the other treatments because the fish in treatment A do not get a source of carotenoids in the feed. On the 40th day, a significant difference was seen in the average color values in treatments B (5%), C (10%) and D (15%) with the average scores in each treatment being 3.60, 4.35 and 4.00 when compared to the average score of treatment A (Control) which was 2.78. It is assumed that the high carotenoid content in the feed will increase the color of the fish so that the color of the fish will become brighter (R. E. Fitriana et al., 2023).

On the 41st to 50th day, fish from all treatments were fed a control feed to observe the impact of stopping the feeding with shrimp head flour content on the brightness of the fish color that had increased. On the 50th day, there was still a slight increase in color in all treatments with the highest increase in color value in treatment C (10%) with an average score of 4.53. These results are in accordance with the results of the research of (Indarti et al., 2012) on comet (Riansah et al., 2020) in koi fish where the cause of the addition of feed wtih 10% shrimp head flour gives better results when compared to treatments that use higher doses is because the astaxanthin content in the feed can be absorbed optimally by the fish because according to (Kurniawati et al., 2012), the more pigments in the feed, the longer it takes for fish to break down carotene into color pigments.

Table 1. Changes in the color value of peacock cichlid on days 0-50

Treatment	Day 0	Day 50	Change
A (Control)	2.32±0.08	2.90±0.03	0.53±0.10[a]
B (5% Shrimp Head Flour)	2.28±0.03	3.72±0.10	1.43±0.12[b]
C (10% Shrimp Head Flour)	2.30±0.05	4.53±0.08	2.23±0.10[b]
D (15% Shrimp Head Flour)	2.32±0.18	4.15±0.09	1.83±0.26[b]

Notes: Different small letters indicate significant differences (Z-test; $p < 0.05$).

The treatment with the highest color change value was treatment C (10%) with a score of 2.23. Meanwhile, the treatment with the lowest value was found in the treatment A (Control) without the addition of shrimp head flour with a score of 0.53 (Figure 2). Based on the multiple comparison of the Z test, treatment C (10%) had a significant difference from treatment A (Control) but did not have a significant difference with treatment B (5%) and D (15%). This shows that the addition of shrimp head flour with different doses has a significant effect on the increase in color brightness in peacock cichlid strain dragon blood. The value of the color increase is higher when compared to the research of (Indarti et al., 2012) in comet goldfish that showed a color increase value of 1.66 in the treatment of 10% shrimp head flour to feed. This can be caused by different species of fish used. According to (Riansah et al., 2020), each fish has a different absorption capacity for carotenoids.

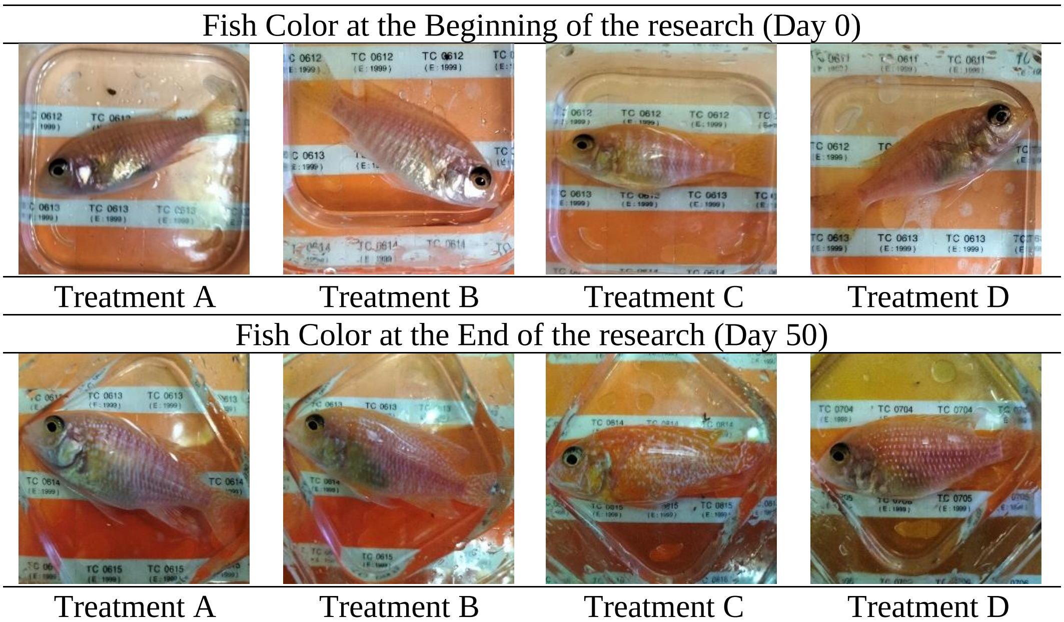

Figure 2. Results of Observation of Peacock Cichlid Color

The color change value showed that treatment C (10%) provided a higher color change value when compared to treatment D (15%) which added the most dose of shrimp head flour. This can be caused by the chitin content in shrimp head flour which inhibits the work of enzymes to digest fat so that the fish's body cannot absorb carotenoids perfectly (N. Fitriana et al., 2013). Treatment D (15%) added the largest dose of shrimp head flour to the feed so that the astaxanthin content contained in the feed could not be absorbed optimally by the fish. In addition, the higher the concentration of astaxanthin in the fish, the longer it takes to synthesize the source of the carotenoid (Guillaume, 2001).

The dosage of carotenoid administration should be considered. This is because the administration of carotenoids has a maximum limit, so if carotenoids are added in excess doses, it will not provide a better increase in color and can even result in a decrease in color value (Sulawesty, 1997). In addition, excessive administration of pigment sources such as carotenoids can decrease hormone performance in fish (Kurniawati et al., 2012).

Absolute Length Growth and Absolute Weight Growth

Based on the results of the F test in analysis of variance (ANOVA) on each treatment, the addition of shrimp head flour to commercial feed with different doses did not have a significant effect on absolute length growth and absolute weight growth. The following are the results obtained from each treatment during the research period (Table 2).

Table 2. Absolute Long Growth of Peacock Cichlid Day 0-50

Treatment	Absolute Length Growth (cm)	Biomass Absolute Weight Growth (grams)
A (Control)	1.21±0.16[a]	11.50±1.91[a]
B (5% Shrimp Head Flour)	1.24±0.16[a]	12,25±3,40[a]
C (10% Shrimp Head Flour)	1.28±0.07[a]	12.75±2.99[a]
D (15% Shrimp Head Flour)	1.29±0.14[a]	13.75±2.63[a]

Notes: Different small letters indicate significant differences (Duncan test; $p < 0.05$).

These results are in accordance with the absolute length growth results in (N. Fitriana et al., 2013) research on (Indarti et al., 2012) research in comet goldfish, where the addition of shrimp head flour did not give a significant results on fish growth. The highest growth in length and absolute weight was found in treatment D (15%) with an absolute length growth of 1.29±0.14 cm and a growth in absolute weight of 13.75±2.63 grams. The absolute length growth was higher when compared to the highest results in the (N. Fitriana et al., 2013) research with an average of 1.16 and lower in absolute weight growth when compared to the highest results in the (Indarti et al., 2012) research with an average of 30.33 grams.

Growth will occur when there is excess energy from the remaining energy used for standard metabolism, digestion and activity (Yandes *et al.,* 2003). Carotenoids such as astaxanthin are categorized as micronutrients in fish feed, so the physiological effects of these compounds are not directly incorporated into somatic growth because they act and provide antioxidant-like effects indirectly on various physiological aspects (NOORI & Alireza, 2017). This makes ornamental fish make more use of pigments obtained from carotenoid sources in feed to improve the body color of the fish (Prayogo et al., 2012).

Shrimp head flour also contains 34.9% chitin (Benjakul, 1993). The chitin content in shrimp head flour is a substance that is difficult to digest because chitin binds to N from the amino acids that make up the protein, making it difficult to digest the protein (Hilkias et al., 2017). If chitin is not utilized or if its utilization is lower than that of proteins and carbohydrates, then at high levels of addition chitin will act as an energy absorbant and limit growth (Karlsen et al., 2017). Shrimp head flour has a high protein content so that the utilization of chitin is not lower when compared to the protein content contained in shrimp head flour. This resulted in all treatments having a relatively same growth.

Water Quality

Water quality is one of the important factors that support the survival of fish. Environmental factors in improper rearing tank can cause stress in fish, affecting the spread of chromatophore cells which can inhibit the increase in color brightness (Saifullah et al., 2023). The parameters observed in this research include physical parameters, namely temperature, and chemical parameters, namely dissolved oxygen (DO), and pH, which are measured every 10 days. The following is the data of the water quality range during the research period (Table 3).

Table 3. Water Quality During Research

Treatment	Water Quality Parameter Ranges		
	Temperature (°C)	DO (mg/L)	pH
A	28.1–30.2	5.1–6.8	8.0–8.4
B	28.0–30.1	4.2–6.3	8.0–8.4
C	28.0–30.0	4.2–6.8	8.0–8.5
D	28.0–30.3	4.9–6.7	8.0–8.5

The results of the water quality analysis showed that the water condition at the time of the research was still at the standard condition. The results of temperature measurements during the research showed that the water temperature in the rearing tank was in the range of 28.0–30.3°C. The temperature range is still in accordance with the tolerance range of fish rearing. According to Kordi and Ghafram (2010), tropical fish live in waters with optimal temperatures ranging from 28.0–32.0°C. An increase in temperature can affect the acceleration of the breakdown of carotenoproteins into proteins and carotene through the metabolic rate of fish so that it can help the formation of red pigment (Latscha, 1990).

The results of dissolved oxygen (DO) measurements during the research showed that the dissolved oxygen level in the rearing tank was in the range of 4.2–6.8 mg/L. The dissolved oxygen level in the water was still feasible for ornamental fish. According to Kottelat *et al.,* (1993), the level of dissolved oxygen that is good for ornamental fish is in the range of 3.0–5.0 mg/L. The metabolic rate of fish can be affected by the dissolved oxygen content in a water (Rosariawari *et al.,* 2019).

The results of pH measurements during the research showed that the pH range in the rearing tank was in the range of 8.0–8.5. The pH range is the ideal range for Malawi cichlid fish such as peacock cichlids because the fish likes alkaline water pH levels. According to (Santos et al., 2023), the optimal pH for cichlids originating from Lake Malawi is 7.7–8.6.

Conclusion

Based on the results of the study, it can be concluded that the addition of shrimp head flour by 5%, 10% and 15% to commercial feed can increase the color brightness of peacock cichlid strain dragon blood (*Aulonocara* sp.) with significantly different results when compared to the control, but there is no significant difference between the treatment with the addition of shrimp head meal. The addition of shrimp head flour by 10% gave the highest result to increase color brightness with an average score of around 4.53 and a color improvement value of 2.2. There was no significant difference in absolute length growth and absolute weight growth between all treatments. The water quality parameters during the research were under normal conditions with a temperature range of 28.0–30.3°C, dissolved oxygen (DO) 4.2–6.8 mg/L and pH 8.0–8.5.

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