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The Influence of differences in the composition of *P. cruentum* and artificial feed on the growth rate and colour intensity of clownfish (*Amphiprion ocellaris*)

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Abstract
Ornamental fish is a fisheries commodity that has the potential for development and a large market opportunity. One of the popular ornamental fish is the clownfish of the species *Amphiprion ocellaris.* Its striking body color serves an important function as a species marker and communication tool in defending its territory. According to Pratiwi *et al*. (2022) [10], the issue with clownfish is a decline in morphological color, which is caused by a deficiency of nutrients related to carotenoids and affects the morphological color of the fish. In the juvenile phase, clownfish require carotenoids to maintain their morphological color (Morais, 2019) [9]. Artificial feed does not contain carotenoids and can be obtained through the consumption of external feed (Salis *et al*., 2019) [11]. The microalga *Porphyridium* sp. contains carotenoids, as well as 56% protein in dry conditions (Safi *et al*., 2013) [12], EPA, DHA, and AA (Li-beisson and Nakamura, 2016) [7]. This research aims to determine the effect of different compositions of *P. cruentum* and artificial feed on the growth rate and color intensity of clownfish (*Amphiprion ocellaris*). This study employed an experimental method with a completely randomized design (CRD). The treatments used were (Treatment A) 25% *P. cruentum* powder in 45 grams of feed, (Treatment B) 50% *P. cruentum* powder in 45 grams of feed, (Treatment C) 75% *P. cruentum* powder in 45 grams of feed, (Treatment D) 100% *P. cruentum* powder in 45 grams of feed. The results showed that the addition of *P. cruentum* powder had a significant effect ($p<0.5$) on the growth rate and color intensity of clownfish (*Amphiprion ocellaris*). The highest growth rate was found in the 100% treatment (Treatment D) with an average of 0.67±0.029%. The highest color intensity of clownfish was also in the 100% treatment (Treatment D) with an average of 26.13±1.10 and a HUE difference of 7.

Keywords: HUE, *P. cruentum,* feed, Production, *A. ocellaris,* clownfish

1. Introduction
Ornamental fish are a potential fishery commodity for development and have a large market opportunity, both domestically and internationally. According to BSN (2023), the export value of ornamental fish from Indonesia reached IDR 542.91 billion in 2022, which accounted for 11.35% of the global market share, up from 8.70% in 2021. This increase placed Indonesia as the second-largest exporter of ornamental fish globally. One of the popular ornamental fish is the clownfish. The clownfish species *Amphiprion ocellaris* is an ornamental fish with unique living habits and a symbiotic relationship with sea anemones (Kilmanun *et al*., 2024) [5]. *Amphiprion ocellaris* has a body color pattern with three chromatophore subtypes: xanthophores interspersed with round melanophores, resulting in orange skin; iridophores that produce white color; and round melanophores that produce black color (Salis *et al*., 2021) [11]. Research conducted by Hayashi *et al*. (2024) [4] shows that white stripes can be an important color pattern to differentiate between competing fish or other fish species competing for territory in clownfish. Striking body colors serve important functions as species markers and also as communication tools in defending their territory. However, the function of these colors can be impaired if the fish do not obtain essential nutrients that support pigment formation. According to Pratiwi *et al*. (2022) [10], the problem in clownfish is the decline in morphological color, caused by a deficiency of nutrients related to carotenoids, which affects the morphological color of the fish. Artificial feed does not contain carotenoids, and carotenoids cannot be synthesized by the fish's body; they can only be synthesized by the fish's body.

They can only be obtained through the consumption of external feed (Salis *et al*., 2019) [11]. Efforts to achieve bright colors in clownfish can be made by utilizing carotenoids to enhance the brightness of the fish's color. Carotenoids are natural pigments found in animals, plants, and algae (Maoka, 2020) [8]. In the seed stage, clownfish need carotenoids to maintain their morphological color (Morais, 2019) [9]. Therefore, carotenoids from microalgae can be utilized. In addition to *Spirulina* Sp the microalgae *Porphyridium cruentum* can be used to provide bright colors to fish. The type of natural feed that can enhance the intensity of fish color is *P. cruentum*. The red microalgae *Porphyridium* has many benefits and is used not only as a source of natural pigments. The microalga *Porphyridium* sp. contains 56% protein in dry conditions (Safi *et al*., 2013) [12], unsaturated fatty acids eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and arachidonic acid (AA) (Li-Beisson and Nakamura, 2016) [7], as well as various types of vitamins such as vitamin A, B, B1, B2, B6, B12, C, E, niacin, biotin, folic acid, and pantothenic acid that act as antioxidants (Tannin-Spitz *et al*., 2005) [18]. The utilization of microalga *Porphyridium* sp. is still not optimal when compared to the utilization of other microalgae such as Spirulina and Chlorella, which are often used as supplements or food additives in powdered form (food supplements) and have good nutrition for human health and are used as animal feed.

The hypothesis to be used in this research is to determine whether there is an effect of the differences in the composition of *P. cruentum* and formulated feed on the growth rate and color intensity of clownfish (*A. ocellaris*).

- **H$_0$:** There is no effect of the differences in the composition of *P. cruentum* and formulated feed on the growth rate and color intensity of clownfish (*A. ocellaris*).
- **H$_1$:** There is an effect of the differences in the composition of *P. cruentum* and formulated feed on the growth rate and color intensity of clownfish (*A. ocellaris*).

2. Materials and Methods

The test fish used for research purposes is the clownfish (*Amphiprion ocellaris*), which originates from the Lampung Marine Cultivation Research Center (BBPBL). The size of the clownfish (*A. ocellaris*) to be used is 2.5-4 cm with an average weight of 0.5±3 grams. The test fish used are clownfish (*A. ocellaris*) in healthy condition, without any wounds on their bodies and swimming actively. The density of the fish in the rearing container is 10 individuals per jar with a volume of 5 liters. The equipment used in this research includes a sprayer bottle, which functions for spraying; a tray, which serves as a container for feed during the drying process. The tools used for data collection consist of a digital scale, which is designed to weigh fish and graph paper, which is employed to measure the length of the fish. Additionally, the tools that support cultivation activities include a hose and an aerator, which function as a generator or supplier of oxygen; a siphon hose, which serves as a siphoning tool; a scoop net, which is used to retrieve fish; and a jar, which serves as a container for feed. The instruments used to measure water quality include a thermometer for measuring temperature; a refractometer for salinity; a pH meter for measuring acidity/pH level; and a Water Quality Checker (WQC), which is employed to measure the dissolved oxygen (DO) content. The test materials used in this study include *P. cruentum* flour, commercial-sized 4 love larva pellets, and clownfish (*A. ocellaris*).

The treatments are as follows:

- **Treatment A:** *P. cruentum* flour added to the commercial feed at a dosage of 25% in 45 grams of feed.
- **Treatment B:** *P. cruentum* flour added to the commercial feed at a dosage of 50% in 45 grams of feed.
- **Treatment C:** *P. cruentum* flour added to the commercial feed at a dosage of 75% in 45 grams of feed.
- **Treatment D:** *P. cruentum* flour added to the commercial feed at a dosage of 100% in 45 grams of feed.

2.1 Research Procedure

2.1.1 Preparation of Containers

The testing containers used in this study are 12 jars with a volume of 5 liters each. The testing containers are first washed with soap and then disinfected using potassium permanganate (PK) to eliminate the presence of pathogenic microorganisms. Subsequently, the testing containers are filled with 3 liters of seawater and equipped with aeration tubing as an oxygen supply for the clownfish (*A. ocellaris*). Once the containers are ready for use, the clownfish are introduced at a density of 10 individuals per container.

2.1.2 Preparation of Test Feed

The feed used during the maintenance process is commercial pellets. The pellets and flour will be mixed using a coating method. According to Purnamasari *et al*. 2022, the coating method involves layering materials with additives using either natural (eggs) or synthetic (CMC) binders. The prepared materials are weighed first using a scale according to the specified dosage. Mix the flour of *P. cruentum* with the binder and place it in a spray bottle. Spray it evenly onto the pellets. The feed is then dried and aired before being stored in a closed jar. This is done to prevent feed spoilage due to mold.

2.1.3 Maintenance of clownfish (*Amphiprion ocellaris*)

The test fish used were clownfish with an average body length of 2.5±4 cm. The stocking density of clownfish juveniles was 10 individuals per 5 liters. The duration of maintenance in this study was 30 days. Feeding was carried out ad libitum with a frequency of twice daily, at 08:00 and 16:00 WIB. Observations on the color intensity of the fish were conducted every 10 days during the 30-day research period.

1.1 Measurement Variables

2.2.1 *Survival rate*

The survival rate of fish is calculated using the formula (Effendie, 2002) [3], that is:

$$SR = \frac{Nt}{No} \times 100\%$$

Description

- **SR:** *Survival rate* (%)
- **Nt:** Number of fish at the beginning of maintenance (individuals)
- **No:** Number of fish at the end of maintenance (individuals)

2.2.2 Absolute Length Growth

The absolute length growth based on Effendi's formula (1979):

$$Pm = Pt - Po$$

Description
- **Pm:** Increase in length (cm)
- **Pt**: Average length at the end of maintenance (cm)
- **Po:** Average length at the beginning of maintenance (cm).

2.2.3 Absolute Weight Growth
Absolute weight growth is calculated based on the Effendie (1997) [2] formula**:**

$$Wm = Wt - Wo$$

Description
- **Wm:** Weight increase (grams)
- **Wt:** Average weight of fish at the end of rearing (grams)
- **Wo:** Average weight of fish at the beginning of rearing (grams).

2.2.4 Efficiency of Feed Utilization
The value of feed utilization efficiency is calculated using the formula by Tacon (1987) [17]:

$$EPP = \frac{Wt - W0}{F} \times 100\%$$

Description
- **W0:** The weight of fish biomass at the beginning of the cultivation (grams)
- **Wt:** The weight of fish biomass at the end of the cultivation (grams)
- **F:** The total amount of fish feed provided during the cultivation (grams)

2.2.5 Specific Growth Rate (SGR)
The growth performance of clownfish (*A. ocellaris*) can be determined from the SGR value based on weight gain (Tacon, 1993) [16].

$$SGR = \frac{Ln\ Wt - LnWo}{t} \times 100\%$$

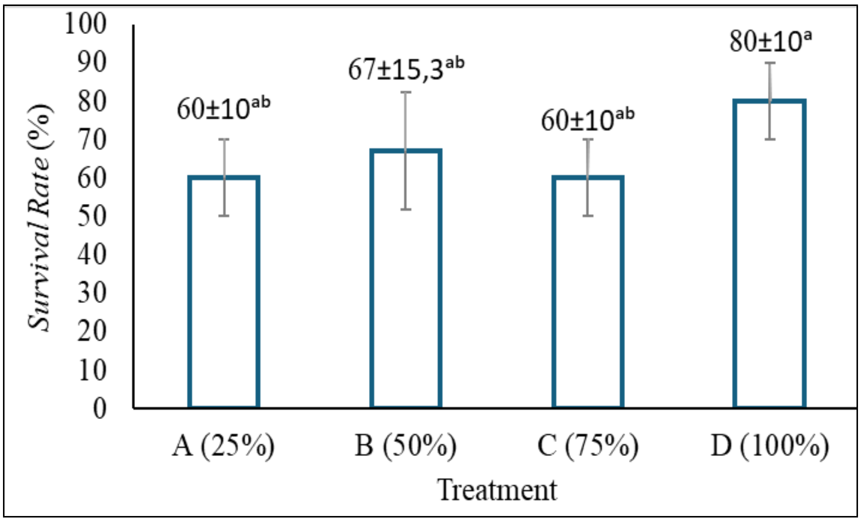
Description
- **SGR:** Specific Growth Rate (%)
- **Wt:** Weight of the fish at the end of rearing (g);
- **Wo:** Weight of the fish at the beginning of rearing (g);
- **T:** Observation time (days)

2.2.6 Color Intensity of Fish
Color observation of fish was conducted using Adobe Photoshop CC software. The observation of clown fish was done by assigning scores on Adobe Photoshop CC, where the weighting started from light orange to dark orange color gradations. The intensity of color in clown fish was observed every 10 days for 30 days, focusing on the orange color. The intensity of the fish's color was measured using Adobe Photoshop CC by sampling the fish and placing it into a cleaned measuring cup. The petri dish containing the fish was placed on a flat surface for easier photography. The petri dish was placed on a white paper base and background to avoid capturing other objects. Photography was done at the same location, time, and lighting conditions, specifically during the daytime. The measurement of the fish's color intensity was conducted every 10 days to observe any color changes, and images of the clown fish samples were applied into the software Adobe Photoshop CC.

2.2.7 Water Quality
The water quality parameters measured in this study include temperature, pH, dissolved oxygen (DO), and salinity. The measurements of temperature and pH were conducted twice daily (at 08:00 WIB and 15:00 WIB) and before feeding, while DO and salinity were measured every ten days.

2.3 Data Analysis
The data generated during this research is statistically processed using SPSS Statistics 26, Microsoft Excel 2019, and Adobe Photoshop CC. The data analysis obtained from the measurements will undergo tests for normality, homogeneity, and additivity. Subsequently, it will be analyzed using ANOVA (Analysis of Variance). If the results of the ANOVA test indicate significant differences among the treatments, further analysis will be conducted using Duncan's test. The water quality data obtained will then be analyzed descriptively and compared with the feasibility values from previous research references.

3. Results
3.1 Survival Rate of *Amphiprion ocellaris:* Based on the research findings, the survival rate (SR) of clownfish (*A. ocellaris*) over a period of 30 days is presented in Figure 1.



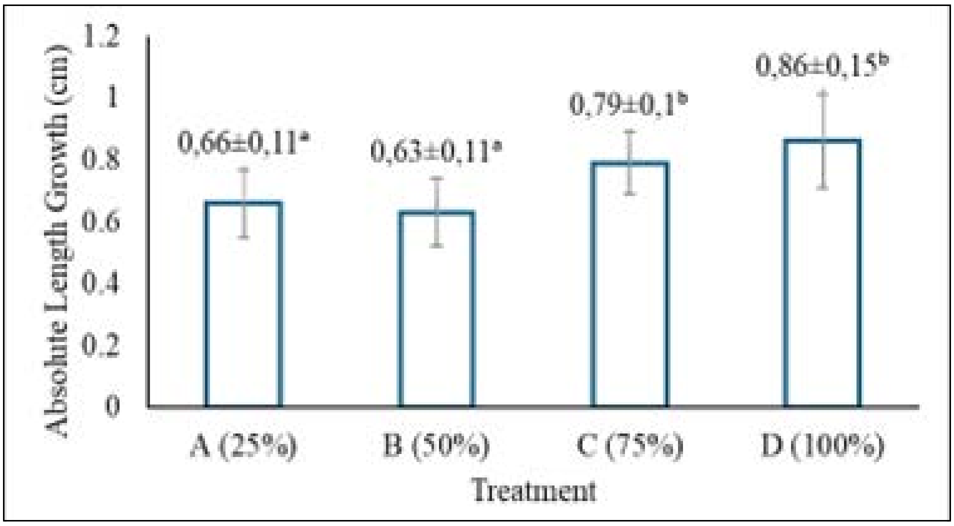
Description: Value with different superscript are significantly different at $p<0.05$

Fig 1: Survival rate graph of Clownfish (*A. ocellaris*)

Based on tests of normality, homogeneity, and additivity, the transformed SR values are normally distributed, homogeneous, and additive, thus meeting the requirements for conducting variance analysis. The results of the variance analysis indicate that the addition of *P. cruentum* flour to the commercial feed has no significant effect (Sig. > 0.05) on the survival rate of clownfish (*A. ocellaris*).

3.2 Absolute Length Growth of *Amphiprion ocellaris*

Based on the research results, the growth rate of the length of clownfish (*A. ocellaris*) over a period of 30 days is presented in Figure 2.



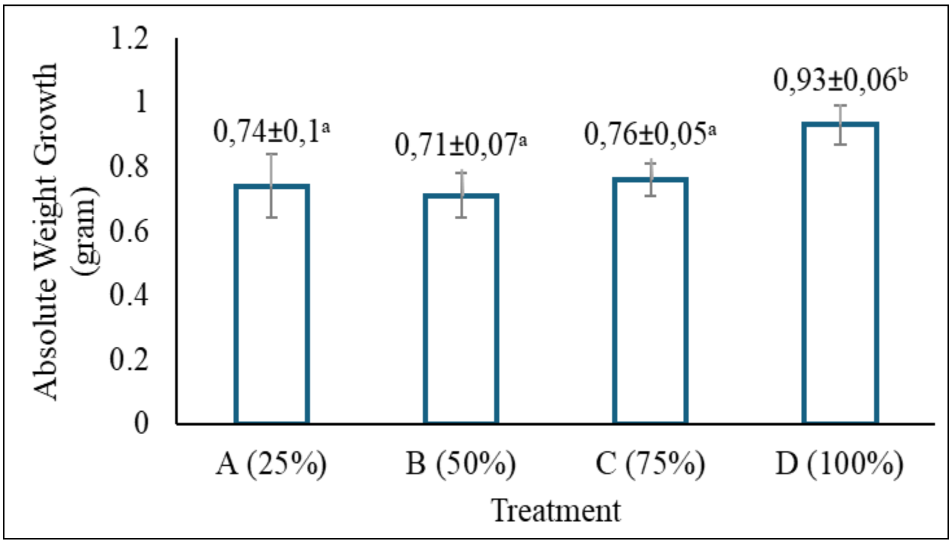
Description: Value with different superscript are significantly different at $p<0.05$

Fig 2: Graph of the Growth of Clownfish Length (*A. ocellaris*)

The research results indicate that the highest length growth occurs with the treatment of 100% *P. cruentum* flour in 45 grams of feed (Treatment D) with an average of 0.86±0.15. The lowest length growth is observed in the treatment of 75% *P. cruentum* flour in 45 grams of feed (Treatment C) with an average of 0.63±0.1. Based on normality, homogeneity, and additivity tests, the length growth values are normally distributed, homogeneous, and additive, thereby meeting the requirements for variance analysis testing. The results of the variance analysis test indicate that the addition of *P. cruentum* flour to commercial feed has a different effect (Sig. > 0.05) on the length growth of clownfish (*A. ocellaris*). Furthermore, Duncan's test is necessary to evaluate the differences in effects among treatments. The results of the Duncan test indicate that the growth rate of clownfish (*A. ocellaris*) length with the treatment of 100% *P. cruentum* flour in 45 grams of feed (Treatment D) is significantly different ($p<0.05$) from the treatment of 75% *P. cruentum* flour in 45 grams of feed (Treatment C), the treatment of 50% *P. cruentum* flour in 45 grams of feed (Treatment B), and the treatment of 25% *P. cruentum* flour in 45 grams of feed (Treatment D).

3.3 Absolute Weight Growth of *Amphiprion ocellaris*

Based on the research findings, the absolute weight growth value of the clownfish (*A. ocellaris*) over a period of 30 days is presented in Figure 3.



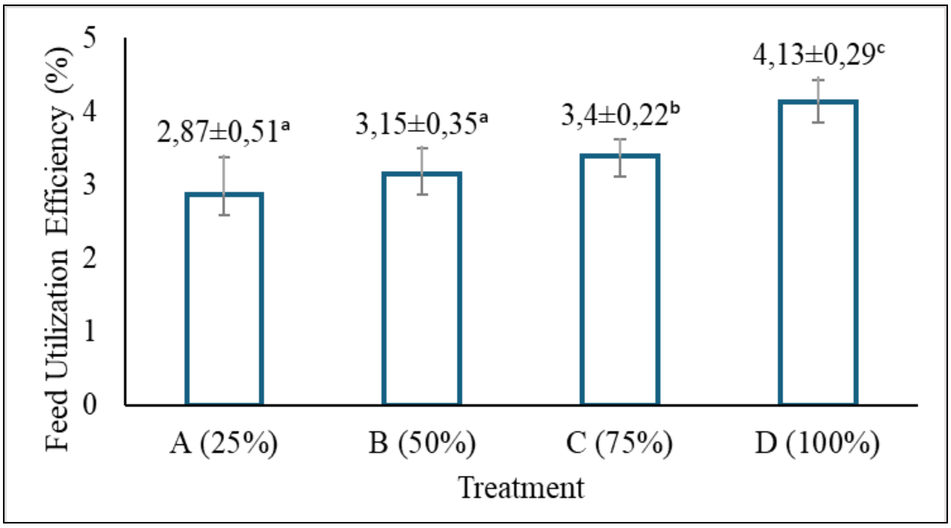
Description: Value with different superscript are significantly different at $p<0.05$

Fig 3: Graph of the Absolute Weight Growth *A. ocellaris*

The research results indicate that the highest absolute weight gain occurred in the treatment with 100% *P. cruentum* flour in 45 grams of feed (Treatment D) with an average value of 0.74±0.106. The lowest absolute weight gain was observed in the treatment with 50% *P. cruentum* flour in 45 grams of feed (Treatment B) with an average value of 0.71±0.079. Based on the normality, homogeneity, and additivity tests, the values of absolute weight gain are normally distributed, homogeneous, and additive in nature, thus meeting the criteria for conducting analysis of variance. The results of the analysis of variance test show that adding *P. cruentum* flour to commercial feed has a significant effect (Sig. < 0.05) on the growth length of clownfish (*A. ocellaris*). Next, a Duncan test is needed to find out the differences in effects among the treatments. The results of the Duncan test indicate that the absolute weight growth of clownfish (*A. ocellaris*) in the treatment with 100% *P. cruentum* flour in 45 grams of feed (Treatment D) is significantly different ($p<0.05$) from the treatment with 50% *P. cruentum* flour in 45 grams of feed (Treatment B), the treatment with 25% *P. cruentum* flour in 45 grams of feed (Treatment A), and the treatment with 75% *P. cruentum* flour in 45 grams of feed (Treatment C).

3.4 Efficiency of Feed Utilization of *Amphiprion ocellaris*

Based on the research results, the efficiency value of feed utilization for clownfish (*A. ocellaris*) over 30 days is presented in the Figure 4.



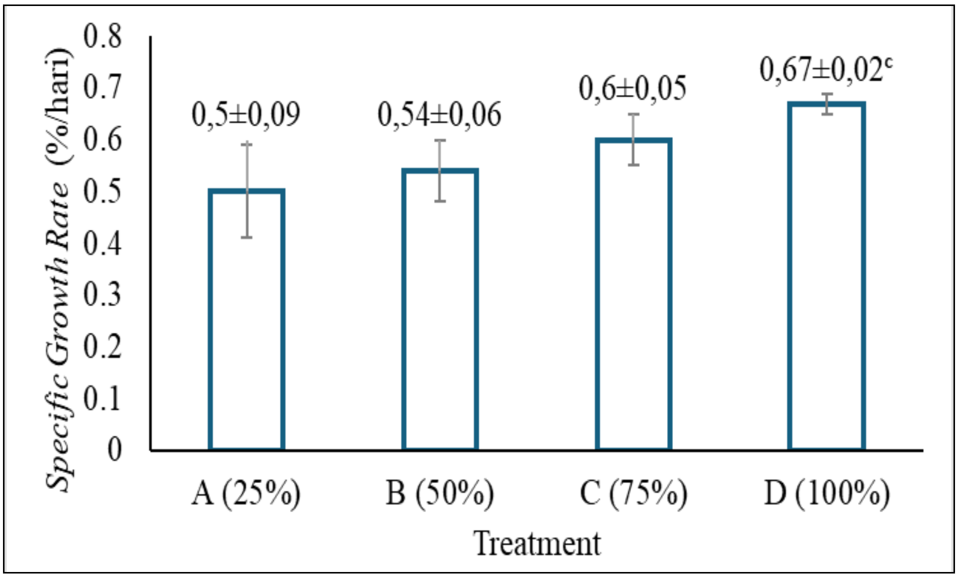
Description: Value with different superscript are significantly different at $p<0.05$

Fig 4: Graph of the Efficiency of Feed Utilization of *A. ocellaris*

The research results indicate that the highest EPP (Feed Efficiency Percentage) is found in the treatment with 100% *P. cruentum* flour in 45 grams of feed (Treatment D), with an average of 4.133±0.029%. Based on normality, homogeneity, and additivity tests, the EPP values are distributed normally, homogeneous, and additive, thus meeting the criteria for variance analysis. The results of the variance analysis test show that the addition of *P. cruentum* flour to commercial feed has a significant effect (Sig. < 0.05) on the growth in length of clownfish (*A. ocellaris*). The Duncan test results indicate that the EPP value in the treatment with 100% *P. cruentum* flour in 45 grams of feed (Treatment D) is significantly different ($p<0.05$) from the treatment with 75% *P. cruentum* flour in 45 grams of feed (Treatment C), the treatment with 25% *P. cruentum* flour in 45 grams of feed (Treatment A), and the treatment with 50% *P. cruentum* flour in 45 grams of feed (Treatment B).

3.5 Specific Growth Rate of *Diaphanosoma* sp.

Based on the research findings, the Specific Growth Rate value of clownfish (*A. ocellaris*) over a period of 30 days is presented in the Figure 6



Description: Value with different superscript are significantly different at $p<0.05$

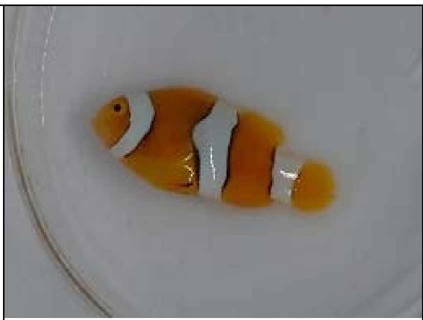
Fig 6: Graph of the specific growth rate of *A. ocellaris*

The research results indicate that the highest Specific Growth Rate (SGR) was observed in the treatment with 100% *P. cruentum* flour in 45 grams of feed (Treatment D) with an average of 0.67%±0.029. The lowest SGR was found in the treatment with 25% *P. cruentum* flour in 45 grams of feed (Treatment A) with an average of 0.50%±0.091. Based on tests for normality, homogeneity, and additivity, the SGR values are normally distributed, homogeneous, and additive, thereby meeting the criteria for conducting an analysis of variance (ANOVA). The results of the ANOVA indicate that the use of *P. cruentum* as an additional raw material in commercial feed has a significant impact (sig. < 0.05) on the growth weight of clownfish (*A. ocellaris*). Furthermore, a Duncan test is required to assess the differences in the effects among treatments. The Duncan test results show that the SGR value in the treatment with 100% *P. cruentum* flour in 45 grams of feed (Treatment D) is significantly different ($p<0.05$) from the treatment with 50% *P. cruentum* flour in 45 grams of feed (Treatment B), the treatment with 25% *P. cruentum* flour in 45 grams of feed (Treatment A), and the treatment with 75% *P. cruentum* flour in 45 grams of feed (Treatment C).

3.6 Color Intensity of Fish

Based on the observations, the results show a change in the color intensity of clownfish (*A. ocellaris*) over 30 days of maintenance. The color intensity score of the clownfish is presented in the Figure 6 and Table 1.

Treatment	Beginning of the research (Day 0)	End of the research (Day 30)
A (25%)	 Hue: 31,86±0,23 **Description:** Bright color before treatment.	 Hue: 29±1 **Description:** The decrease in Hue value is indicated by the orange color, as well as the more pronounced white lines, particularly in the head and body areas. There is a thin black line on the anal fin.
B (50%)	 Hue: 32.46±0.41 **Description:** Bright color before treatment.	 Hue: 29.13±0.80 **Description:** There is a decrease in the Hue value, but the orange color appears sharper and more contrasting, especially in the area close to the operculum, head, and middle part of the body. The pattern of black lines on the abdomen and anal fin is sharper.
C (75%)	 Hue: 32,86±0,23 **Description:** Bright color before treatment.	 Hue: 28.06±1.00 **Description:** A decrease in the Hue value is indicated by a more intense and bright orange color. The white lines appear distinctly contrasted and defined, particularly in the head and central body area.

D (100%)	 Hue: 33,13±0,30 **Description:** Bright color before treatment.	 Hue: 26,13±1,10 **Description:** The orange color appears increasingly intense and uniform across the entire body. The contrast between the orange color and the white lines is sharp, particularly in the head and tail area.

Description: The orange color appears to be increasingly vibrant and evenly distributed across the body. The contrast between the orange color and the white lines looks sharp, especially in the head and tail areas.

Based on Figure 6, it was found that the Hue value decreased over the 30-day study period. The decline and difference in Hue values are presented in Table 1.

Table 1: The decline and difference in hue values are presented

Treatment	Hue Value Day 0	Hue Value Day 10	Hue Value Day 20	Hue Value Day 30	Difference in Hue Value
A (25%)	31.86±0.23	31.06±0.92	30.6±0.57	29±1	2.86±1.20^{a}
B (50%)	32.46±0.41	31.86±0.41	30.8±0.34	29.13±0.80	3.33±1.46^{a}
C (75%)	32.86±0.23	32.26±0.30	29.8±0.69	28.06±1.00	4.83±2.23^{b}
D (100%)	33.13±0.30	32.86±1.11	29.6±0.30	26.13±1.10	7.0±3.29^{c}

Description: The decrease in Hue values for each treatment reflects an increase in brightness.

Based on Table 1, a reduction in Hue values is observed over time in all treatments. On day 0, the highest Hue value was found in the treatment with 50% *P. cruentum* flour in 45 grams of feed (Treatment B), which was 32.46±0.41°, while the lowest was in the treatment with 25% *P. cruentum* flour in 45 grams of feed (Treatment A), which was 31.86±0.23°. On day 30, the highest Hue value was again in the treatment with 50% *P. cruentum* flour in 45 grams of feed (Treatment B), at 29.13±0.80°, while the lowest value was noted in the treatment with 100% *P. cruentum* flour in 45 grams of feed (Treatment D), which was 26.13±1.10°. The highest difference in the decline of Hue value occurred in the treatment of 100% *P. cruentum* flour in 45 grams of feed (Treatment D) with a difference of 7°, followed by the 75% treatment (Treatment C) with a decline of 4.83°, the 50% *P. cruentum* flour treatment in 45 grams of feed (Treatment B) with a decline of 3.33°, and the lowest in the 25% *P. cruentum* flour treatment in 45 grams of feed (Treatment A) with a decline of 2.86°. The greater the decline in Hue value indicates an increase in the orange color intensity of clown fish. Therefore, the treatment of 100% *P. cruentum* flour in 45 grams of feed (Treatment D) resulted in the highest increase in color intensity over a 30-day maintenance period. Normality, homogeneity, and additivity tests were conducted on the color intensity scores of clown fish. The test results indicated that the data were homogeneous and that the additivity analysis showed the data was additive, thus meeting the criteria for analysis of variance. The results of the analysis of variance indicate that the addition of *P. cruentum* flour to commercial feed has a statistically significant effect (Sig. < 0.05) on the color intensity of clownfish (*A. ocellaris*). Duncan's test results show that the color intensity value of clownfish (*A. ocellaris*) in the treatment with 25% *P. cruentum* flour in 45 grams of feed (Treatment A) is significantly different ($p<0.05$) from the treatment with 75% *P. cruentum* flour in 45 grams of feed (Treatment C) and the treatment with 100% *P. cruentum* flour in 45 grams of feed (Treatment D) concerning color intensity. The treatment with 50% *P. cruentum* flour in 45 grams of feed (Treatment B) falls within two overlapping groups, thus showing no significant difference when compared to either Treatment A or Treatment C. The results of the paired t-test indicate that the mean difference value is 25.63, with a calculated t value of 46.761 and a significance level (Sig. 2-tailed) of 0.000. Since the significance value is less than 0.05, it can be concluded that there is a significant difference between the intensity of color and the treatment provided.

3.7 Water Quality

Based on the research findings, the water quality parameters measured during the 30-day maintenance period of clownfish can be seen in the Table 2.

Table 2: Water quality of *A. ocellaris*

Kisaran Nilai Parameter Kualitas Air				
Perlakuan	**Suhu (°C)**	**pH**	**DO (mg/L)**	**Salinitas (ppt)**
25%	29-32	6.8-8.5	3.5-4.8	30-33
50%	29-32	7.5-8.6	3.5-4.8	30-33
75%	29-32	7.1-8.6	3.5-4.3	30-33
100%	29-32	7.1-8.6	3.5-5.5	30-33
Standard	27-32	6.7-8.6	3.5-6.5	25-40

The results of the measurement of the range of water quality parameter values based on Table 2 indicate that the ranges of temperature, pH, and DO for each treatment are still within acceptable conditions.

4. Discussion
4.1 Specific growth rate
This research demonstrates that the addition of the red microalga *Porphyridiumcruentum* in feed has a significant impact on the growth, feed utilization efficiency, survival rate, and color intensity of clownfish (*Amphiprion ocellaris*). The results indicate that treatment D, which involves the use of 100% *P. cruentum* flour in 45 g of feed, produced the best performance compared to other treatments. In this treatment, the specific growth rate (SGR) reached 0.679±0.029% per day, which is higher than the normal growth range of clownfish reported as 0.27-0.34% per day. The absolute length growth was also greater, measuring 0.86±0.15 cm, with an absolute weight increase of 0.93±0.06 g. This condition indicates that the nutrients from *P. cruentum* can be optimally utilized in the formation of new tissues. The growth of fish is influenced by internal factors such as age, and external factors such as water quality, stocking density, and feed management. At low stocking densities, fish have more room to move and experience less competition, allowing for better growth. Conversely, high density causes stress, dominance of certain individuals, and competition for feed, which ultimately reduces growth. The nutritional quality of feed is a key factor in growth. Commercial feed combined with *P. cruentum* provides high protein (52%) as well as essential fatty acids such as EPA, DHA, and AA, which play important roles in tissue formation, metabolism, immunity, reproduction, and the development of the nervous system. Protein serves as a building block for body tissues, while fats and carbohydrates are the primary sources of energy.

4.2 Color intensity of fish
In this study, the administration of *Porphyridiumcruentum* flour showed a significant effect on the decrease in hue values of clownfish. On day 0, the highest hue value was recorded in the treatment with 50% *P. cruentum* flour in 45 grams of feed (Treatment B), with a value of 32.46±0.41°, while the lowest value was found in the treatment with 25% *P. cruentum* flour (Treatment A) at 31.86±0.23°. After 30 days of maintenance, the highest hue value was still found in the treatment with 50% *P. cruentum* flour (Treatment B) at 29.13±0.80°, while the lowest value was achieved in the treatment with 100% *P. cruentum* flour (Treatment D) at 26.13±1.10°. The largest decrease in hue value occurred in the treatment with 100% *P. cruentum* flour (Treatment D) amounting to 7°, followed by the treatment with 50% (Treatment C) at 4.83°, the treatment with 100% (Treatment B) at 3.33°, and the treatment with 25% (Treatment A) at 2.86°. The factors influencing the color intensity of clownfish include genetics, age, carotenoids, and water quality. Genetics plays a significant role as genes regulate the type and distribution of pigment cells in the fish's skin. Differences in the absorption levels of dietary pigments in each individual lead to variations in color across different treatments (Yunitasari *et al*., 2025) [20]. Skin pigmentation is determined by the type and distribution of pigment cells in the chromatophores found in the dermis, epidermis, and around the neurovascular areas in response to certain stimuli. The colors produced result from light absorption or interference phenomena by light-reflecting substances. Clownfish have three types of pigment cells, namely melanophores (black), xanthophores (orange/red), and iridophores (white). Iridophores not only provide a white color but also play a role in the proper placement of melanocytes. Each species has the capacity for color change with a specific combination of chromatophore cells to adapt to the environment (Tume *et al*., 2009) [19]. Light can trigger pigment pattern migration (Kusumawati, 2011), and differences in light stimulation levels affect the physiological and biological responses of fish. The formed pigment patterns are phenotypic characteristics inherited from the parents and are controlled by specific genes with a particular nucleotide sequence (Sugie *et al*., 2004) [14]. Carotenoids are important pigments that fish obtain from their feed because they cannot synthesize them on their own. Amino acids in *P. cruentum* support pigment synthesis by enhancing protein and enzyme production, including tyrosine as a precursor to melanin (Kumari *et al*., 2022) [6], as well as phenylalanine, which plays a role in pteridine synthesis (Scardua *et al*., 2024) [13]. Polyunsaturated fatty acids (PUFA) such as EPA and ARA maintain the integrity of pigment cell membranes and reduce oxidative stress (Amalia *et al*., 2023 [1]). Color formation is also influenced by the location and quantity of carotenoids stored in the skin (Sinha, 2022), the processes of pigment transportation and deposition, as well as the size of chromatophores.

4.3 Water Quality
Water quality is a crucial factor determining the survival, growth, and physiological performance of clownfish (*Amphiprion ocellaris*). Research findings indicate that water temperatures range from 29-32 °C, which are still within the tolerance range, though approaching the upper limit of the optimal temperature of 26-30 °C. Low temperatures can reduce appetite and increase susceptibility to diseases, while high temperatures may induce respiratory stress and gill damage. The measured pH values are between 6.8-8.6, generally still within the safe range of 7.5-8.5 (SNI, 2012), although fluctuations down to 6.8 should be monitored as they can disrupt osmoregulation and fish growth. Dissolved oxygen (DO) concentrations recorded at 3.5-4.9 mg/L are relatively safe but approaching the minimal optimal threshold of ≥4 mg/L. Therefore, the stability of Dissolved Oxygen (DO) must be maintained to prevent stress, which is indicated by behaviors such as swimming to the surface or loss of balance. The salinity ranges from 30 to 33 ppt, in accordance with the optimal standard of 29 to 32 ppt., thereby supporting the physiological activity and osmotic balance of the fish. Overall, the water quality in this study remains within the tolerance range for the maintenance of clownfish, although attention must be given to the stability of temperature, pH, and DO to avoid exceeding critical limits that could impact growth, health, and survival (Syazili *et al*., 2022 [15]).

5. Conclusion
Based on the research conducted on the influence of differences in the composition of P. cruentum and artificial feed on the growth rate and color intensity of clownfish (*A. ocellaris*), the following conclusions can be drawn: The use of *P. cruentum* flour in artificial feed has a varying effect on the color intensity of the fish, absolute length growth, absolute weight growth, Feed Efficiency Ratio (EPP), and Specific Growth Rate (SGR), whereas it has the same effect on Survival Rate (SR). The highest growth rate was observed in the 100% treatment (Treatment D) with an average of 0.67±0.029%. The highest color intensity of clownfish was

also recorded in the 100% treatment (Treatment D) with an average of 26.13±1.10 and a HUE difference of 7.

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