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The effectiveness of dragon fruit peel *Hylocereus polyrhizus* in feed on color quality and growth performance of comet fish *Carassius auratus*

Efektivitas pemberian tepung kulit buah naga *Hylocereus polyrhizus* dalam pakan terhadap kualitas warna dan performa pertumbuhan ikan komet *Carassius auratus*

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ABSTRACT

Color is a defining trait of ornamental fish, crucial for their aesthetic appeal, but it diminishes without pigment supplementation in their diet. Utilizing dragon fruit skin as a natural feed constituent offers a promising method to intensify fish coloration. This investigation aims to assess the impact of incorporating dragon fruit skin meal into fish feed on color vibrancy and growth performance, specifically focusing on comet fish. The test subjects, ranging from 4 to 6 cm in size and weighing 3.1 ± 0.2 grams, underwent examination. Employing a completely randomized design (CRD), the study involved four treatments replicated four times: treatment A (control), B (5% dragon fruit skin meal addition), C (10% addition), and D (15% addition). Before commencing the study, a preliminary assessment of dragon fruit skin meal was conducted, encompassing a chromameter-based color pigmentation test. Results revealed positive a (red) and b (yellow) values, a chroma value of 26.32 signifying carotenoid pigments, a hue value of 3.18° indicating a red-orange hue, and an antioxidant activity test exhibiting moderate antioxidant activity was observed, indicating the presence of antioxidant compounds. Findings demonstrated that a 15% addition of dragon fruit skin meal substantially enhanced color vibrancy across the fish's body sections, including the head, body, and tail. Although fish weight and length were influenced by the feed amendment, ANOVA analysis did not ascertain significant effects. Furthermore, treatment C exhibited the most favorable feed conversion ratio and specific growth rate, recording values of 0.09 ± 0.03 and 0.934 ± 0.215, respectively.

Keywords: color brightness, comet fish, dragon fruit peel flour

ABSTRAK

Warna merupakan ciri khas yang dimiliki oleh ikan hias, yang akan memudar bila tidak ada tambahan pigmen dalam pakan. Kulit buah naga dapat digunakan sebagai bahan pakan alami untuk meningkatkan kecerahan warna pada ikan. Riset ini bertujuan untuk mengetahui pengaruh pemberian tepung kulit buah naga dalam pakan terhadap kualitas warna dan performa pertumbuhan ikan komet. Ikan uji berukuran 4-6 cm dengan bobot 3,1 ± 0,2 gram. Metode riset yang digunakan yaitu metode eksperimental dengan menggunakan rancangan acak lengkap (RAL) yang terdiri dari empat perlakuan dan empat ulangan yaitu perlakuan A (kontrol), B (penambahan tepung kulit buah naga 5%), C (penambahan tepung kulit buah naga 10%) dan D (penambahan tepung kulit buah naga 15%). Sebelum penelitian dilakukan uji pendahuluan pada tepung kulit buah naga yaitu uji pigmentasi warna menggunakan chromameter diperoleh hasil nilai a positif (merah) dan b positif (kuning), nilai chroma 26,32 artinya terdapat kandungan pigmen karotenoid, nilai hue 3,18° menunjukkan warna orange merah, serta uji aktivitas antioksidan dengan hasil aktivitas antioksidan yang kurang aktif namun tetap memiliki kandungan antioksidan. Hasil riset menunjukkan bahwa penambahan tepung kulit buah naga 15% dalam pakan dapat meningkatkan kualitas warna yang optimal pada tubuh ikan yaitu kepala, badan dan ekor. Penambahan tepung kulit buah naga dalam pakan dapat mempengaruhi bobot dan panjang ikan namun di uji lanjut menggunakan analisis ANNOVA tidak memberikan pengaruh nyata. Penambahan tepung kulit buah naga juga memberikan nilai konversi pakan dan laju pertumbuhan spesifik terbaik pada perlakuan C dengan nilai 0,09 ± 0,03 dan 0,934 ± 0,215.

Kata kunci: kecerahan warna, ikan komet, tepung kulit buah naga

INTRODUCTION

The increasing demand for ornamental fish necessitates a consistent and large-scale supply. This demand can be met through the collection of wild catches or through aquaculture practices (Yusniarti *et al.,* 2018). From 2010 to 2019, the global export value of ornamental fish averaged USD 352.88 million per year, with an annual growth rate of 0.61% (Suhana & Marlianingrum, 2021). According to the Directorate General of Aquaculture (DJPB, 2022), Indonesia's ornamental fish production volume in the third quarter of 2022 reached 1.14 billion individuals, which accounted for 78.62% of the third-quarter target of 1.45 billion individuals. In the same quarter, Indonesia's ornamental fish exports were valued at USD 26.07 million, consisting of USD 21.01 million from freshwater species and USD 5.06 million from marine species. This represented a 0.77% increase in export value compared to 2021 (Suhana, 2022).

One of the key freshwater ornamental fish commodities in Indonesia is the comet fish (*Carassius auratus*). The comet is a strain of goldfish resulting from crossbreeding various carp species, endowing it with a stronger immune system than traditional goldfish (Sumantri *et al.,* 2017). Comet fish possess several fins, including pectoral, dorsal, and caudal fins. The caudal fin is notably larger than the body length, with a long, branched, and flowing structure (Puspitasari *et al.,* 2019). Comets are capable of spawning year-round, particularly during the rainy season, and can reproduce both naturally and artificially (Izzah *et al.,* 2020).

The comet fish is distinguished by its koi-like body shape and goldfish-like tail, with vibrant color combinations of yellow, orange, gold, and white, contributing to its high economic value. Color vibrancy represents a critical attribute in ornamental fish aesthetics (Septiyan *et al.,* 2017). The commercial value of comet fish is strongly influenced by the brightness of its coloration brighter specimens fetch higher market prices, as pigmentation quality is a primary determinant of ornamental fish value (Hafiz *et al.,* 2020). Color quality in fish is determined by chromatophores (pigment cells) located in the epidermal layer. These cells are responsive to environmental and reproductive cues; thus, the quantity and mobility of chromatophores significantly affect pigmentation intensity (Nyquist, 1997; Rosid *et al.,* 2019). Without the presence of pigmentation compounds such as carotenoids, ornamental fish including comet fish tend to exhibit faded coloration.

However, aquatic animals are incapable of synthesizing carotenoids endogenously (Amin *et al.,* 2012). Therefore, dietary supplementation with natural colorant-rich ingredients is essential to enhance pigmentation (Yusniarti *et al.,* 2018). Common pigment supplements in ornamental fish feed include maggot meal, *Spirulina platensis* powder, and astaxanthin (Sutarjo *et al.,* 2023). Astaxanthin is a potent carotenoid frequently used to enhance ornamental fish coloration (Phonna *et al.,* 2022). It is considered one of the most effective and bioavailable carotenoids for intensifying red pigmentation, as fish readily absorb astaxanthin from feed and deposit it directly into chromatophores (Indarti *et al.,* 2012). Pigmentation in fish is generally classified into three types: melanin (black), erythrin (red), and xanthin (yellow), with other hues resulting from combinations of these base pigments (Meilisza, 2023).

Carotenoids can be sourced from various natural resources, as they are biosynthesized by plants (fruits and vegetables), algae, and aquatic organisms. Their presence is usually indicated by vibrant orange or red hues in plant tissues (Syukri, 2021). One such carotenoid-rich fruit is the dragon fruit (*Hylocereus polyrhizus*), which has been cultivated in Indonesia since 2000 and is highly favored for its nutritional value and health benefits. The rising market demand has led to increased production, reaching 82,544 tons per hectare in 2020 (Menpan, 2022).

However, approximately 30–35% of the dragon fruit, primarily the peel, is discarded as waste (Saati, 2010), with total waste volume reaching around 40,000 tons (Fath *et al.,* 2024). The red or purplish-red peel contains natural pigments and antioxidants (Haerawati & Sambara, 2024), making it a viable natural colorant for aquafeeds as a source of carotenoids. Dragon fruit peel is nutritionally valuable, containing 8.98% protein, 25.09% crude fiber, 1.32% fat, and 0.56 ppm anthocyanins (Astlianti & Nasukha, 2012). Dragon fruit peels exhibit strong antioxidant activity, with 1 mg/mL of peel extract inhibiting free radicals by 83.48 ± 1.02%, compared to only 27.45 ± 5.03% inhibition from the fruit pulp (Aiyuni *et al.,* 2017).

The peel also contains various bioactive compounds, including flavonoids, polyphenols, betalains, and a high level of β-carotene at 3.452

ppm (Satria & Marhayani, 2020; Haerawati & Sambara, 2024). Despite this, dragon fruit peel remains underutilized as a natural pigment source in aquaculture (Slamet *et al.,* 2022). This study aimed to evaluate the effect of dietary supplementation with dragon fruit peel (*Hylocereus polyrhizus*) powder at various concentrations on the enhancement of coloration and growth performance of comet fish (*Carassius auratus*).

MATERIALS AND METHOD

This study employed an experimental method designed using a completely randomized design (CRD), consisting of four treatments and four replications. The treatments tested involved the supplementation of dragon fruit peel powder in the feed at different concentrations, namely A (commercial feed only), B (commercial feed + 5% dragon fruit peel powder), C (commercial feed + 10% dragon fruit peel powder), and D (commercial feed + 15% dragon fruit peel powder).

Experimental preparation

Tested materials

A total of 160 comet fish juveniles were used as the experimental subjects. The juveniles were one month old, measuring 4–6 cm in length with an average body weight of 3.1 ± 0.2 grams. These specimens were obtained from the Freshwater Aquaculture Center (Balai Besar Perikanan Budidaya Air Tawar), Sukabumi. Dragon fruit peels, used as a feed supplement, were collected from local fruit vendors and neighborhood residents, totaling 4 kg. The commercial feed used was the *Sakura* brand, purchased from a local aquaculture feed store, with the following nutritional composition: crude protein 30–35%, minimum crude fat 3%, maximum crude fiber 4%, maximum ash content 12%, and maximum moisture content 12%. A commercial feed binder, progol booster (100 grams), was also purchased for the purpose of binding the test feed.

Feed testing procedure

The comet fish juveniles were reared in 16 glass aquaria, each measuring 40×30×32 cm³, which served as the experimental tanks throughout the study. After an acclimation period, 10 fish were stocked into each aquarium, maintaining a stocking density of 1 fish per liter. The rearing period lasted for 40 days. Feed was administered at a daily rate equivalent to 8% of the total biomass and was given three times per day at 08:00, 12:00, and 16:00 WIB. Maintenance of the aquaria was carried out daily, including partial water replacement every two days (20–30% of the total water volume).

Data collection

Initial color observations were made on three anatomical regions of the comet fish: head, body, and caudal fin. Color brightness assessments were conducted three times on day 0 (baseline), day 20 (midpoint), and day 40 (final) by comparing the coloration of the test fish to the tocca color finder (TCF) standard scale. The visual assessments were performed by five non-color-blind panelists. In addition, initial weight and total length of each fish were recorded. Survival rate was monitored daily by counting the number of surviving fish from the beginning to the end of the study. Feed conversion ratio (FCR) was determined by recording the weight of dead fish and calculating biomass gain. Water quality parameters, including temperature, dissolved oxygen (DO), and pH, were measured every seven days.

Experimental procedure

Preparation of test feed

Fresh dragon fruit peels were obtained from fruit vendors and local residents around the research site to be used as an ingredient in the feed formulation for this study. The dragon fruit peels were cleaned, washed, and then cut into small pieces. They were dried in an oven at 40°C for 4–6 hours. After drying, the peels were blended into a fine powder. From 1 kg of fresh dragon fruit peel, 200 grams of dragon fruit peel powder (20%) were produced. The commercial feed, which was also finely ground, was then mixed with the dragon fruit peel powder according to the treatment doses using a disc mill. To improve the feed's cohesion, 5 g of Progol per kg of feed was added as a binder, followed by the addition of 40% water to ensure the feed mixture was evenly blended. After mixing, the test feed was pelletized using a 1 mm pellet forming machine, and the pellets were air-dried under natural sunlight for 24 hours.

Testing of dragon fruit peel

The finely ground dragon fruit peel powder was analyzed for its pigment potential, which included antioxidant activity testing using the DPPH method and color pigmentation tests.

The antioxidant activity was measured using UV-VIS spectrophotometry at a wavelength of 517 nm. The color test was conducted using a Konica Minolta CR-400 chromameter. Following these tests, the test feed was prepared by mixing the commercial feed with the dragon fruit peel powder. The test feed was administered for a period of 40 days during the maintenance phase. Color observations were made three times, while weight, length growth, and water quality were monitored every seven days.

Data collection

The comet fish seeds, which had been fed the experimental feed, were observed for color changes on various body parts using tocca color finder (TCF) paper. The color observations were conducted three times: on day 0, day 20, and day 40. These observations were made by five panelists, who assessed three parts of the fish: the head, body, and tail. The survival rate was monitored from the beginning to the end of the study by counting the number of live fish at the start and end of the research period. Additionally, water quality measurements, including temperature, dissolved oxygen, and pH, were taken every seven days.

Analytical methods

Antioxidant activity assay

The antioxidant activity was measured using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method with a UV-VIS spectrophotometer. The first step involved preparing a 160 ppm DPPH solution: 4 mg of DPPH powder was weighed and dissolved in 25 mL of methanol in an amber vial. Then, 800 µL of methanol was pipetted into a brown test tube, followed by the addition of 200 µL of the DPPH solution. The mixture was incubated for 30 minutes at room temperature. After incubation, the absorbance of the DPPH solution was measured at a wavelength of 517 nm using a UV-VIS spectrophotometer.

The second step was the preparation of the sample stock solution at 10,000 ppm. A total of 0.1 g of the sample was weighed and placed into a 10 mL volumetric flask. Methanol was added up to the mark, and the mixture was homogenized using a sonicator until fully dissolved. The sample solution was then centrifuged at 10,000 rpm for 10 minutes. The resulting filtrate was collected for analysis.

In the third step, the stock solution was diluted to obtain sample concentrations of 1,000 ppm and 100 ppm by adding methanol and DPPH, adjusting the final volume to 1 mL. The samples were incubated for 30 minutes at room temperature. The absorbance of each sample was measured at 517 nm using a UV-VIS spectrophotometer. The absorbance values were used to determine the concentration variation for further analysis. Finally, the percentage of inhibition and the IC_{50} value were calculated. A lower IC_{50} value indicates higher antioxidant activity of the sample.

Color pigmentation test

Color analysis was performed using a Konica Minolta CR-400 chromameter. The initial step involved connecting Device 1 (sensor head) and Device 2 (processor) using the supplied cable. The processor was then connected to a power source via the provided adapter. Both devices were turned on by switching the main power switch to the ON position, and the system was allowed to complete its detection process (displaying L*, a*, b* or X, Y, Z values). Prior to use, the instrument was calibrated using a standard calibration plate.

Feed conversion ratio (FCR)

According to Effendi (1997), the feed conversion ratio can be calculated using the following formula:

$$FCR = \frac{F}{(Wt + D) - W0}$$

Note:

FCR = Feed conversion ratio

W_0 = Initial weight of the test fish (grams)

W_t = Final weight of the test fish (grams)

D = Weight of dead fish during the study (grams)

F = Total amount of feed given (grams)

Data analysis

The survival rate, absolute growth, specific growth rate, feed conversion ratio, and the relationship between length and weight were analyzed using Analysis of Variance (ANOVA) with a 95% confidence level. If significant differences were found, a Duncan's Multiple Range Test was performed. The color brightness analysis was evaluated using the Kruskal-Wallis Test, and water quality data were analyzed descriptively.

RESULTS AND DISCUSSION

Results

Test of dragon fruit peel pigment potential

Two tests were performed to assess the pigment potential of dragon fruit peel: the antioxidant activity analysis using DPPH and the color pigmentation test using a chromameter. The results of the antioxidant activity analysis (Table 1 and Table 2) and the color pigmentation test (Table 3) are shown below.

Color brightness level on the body of fish

Based on the observations conducted over a period of 40 days, it was found that the addition of dragon fruit peel powder in the feed had an impact on the coloration of the comet fish. The body color of the comet fish was observed three times during the study, namely on day 0, day 20, and day 40. The development of the body color and the average quality of the comet fish's body color, based on the TCF (tocca color finder) scale, from the beginning to the end of the study, is shown in Figures 1 and 2. The results demonstrated a noticeable improvement in the fish's color, with a marked enhancement in brightness and color intensity as the study progressed. The dragon fruit peel powder, which is rich in natural pigments such as anthocyanins, contributed to the enhancement of the fish's pigmentation, especially in the red and yellow areas of the fish's body. These color changes indicate that the supplementation of dragon fruit peel powder in the feed can be an effective method for improving the aesthetic quality of ornamental fish like comet fish.

Survival rate

Based on the observational data, the addition of dragon fruit peel powder to the feed did not negatively affect the survival of comet fish. All treatment groups including the control (A) and the three supplementation levels (B, C, and D) achieved a 100% survival rate throughout the 40-day rearing period. In Figure 3, the survival rate of comet fish in all treatment groups reached 100%. This is presumably due to the provision of nutritionally balanced feed and optimal water quality, indicating that the fish were able to adapt well to the experimental conditions.

Furthermore, the high survival rate may also be attributed to the bioactive compounds present in dragon fruit peel powder. According to Efianda *et al.* (2020), dragon fruit peel contains polyphenols, which function as antioxidants and

Table 1. Antioxidant Activity Data (DPPH).

Sample	IC_{50} (ppm)		Total average
	1st replication	2nd replication	
Dragon fruit peel powder	5720.6265	5743.2169	5731.9217

Table 2. Antioxidant activity data of dragon fruit peel.

No.	Concentration (ppm)	Absorbance		% of inhibition	
		1st replication	2nd replication	1st replication	2nd replication
1.	0	0.7186	0.7186	0.0000	0.0000
2.	1600	0.5978	0.5959	16.8105	17.0749
3.	3200	0.5020	0.5068	30.1419	29.4740
4.	4800	0.4013	0.4008	44.1553	44.2249
5.	6400	0.3147	0.3142	56.2065	56.2761
6.	8000	0.2436	0.2386	66.1008	66.7965

Table 3. The results of color pigmentation test.

No	Parameters	Analysis results
1.	L*	49,63
2.	a*	26,28
3.	b*	1,46

Note: L (*lightness)*, a+ (red) dan b+ (yellow).

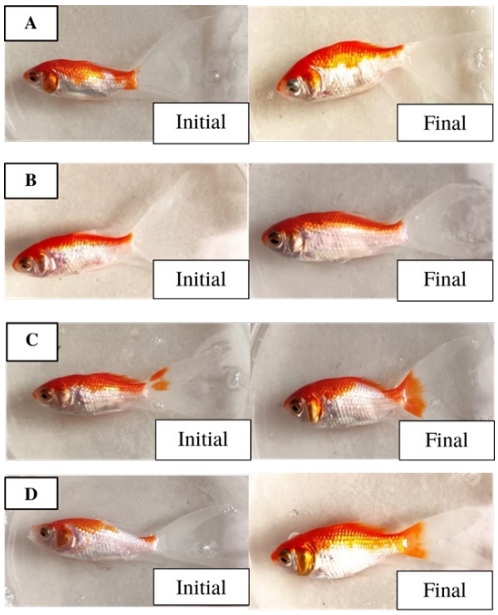

Figure 1. Observation results of body color brightness levels. (A) control (no dragon fruit peel powder added); (B) addition of 5% dragon fruit peel powder; (C) addition of 10% dragon fruit peel powder; (D) addition of 15% dragon fruit peel powder.

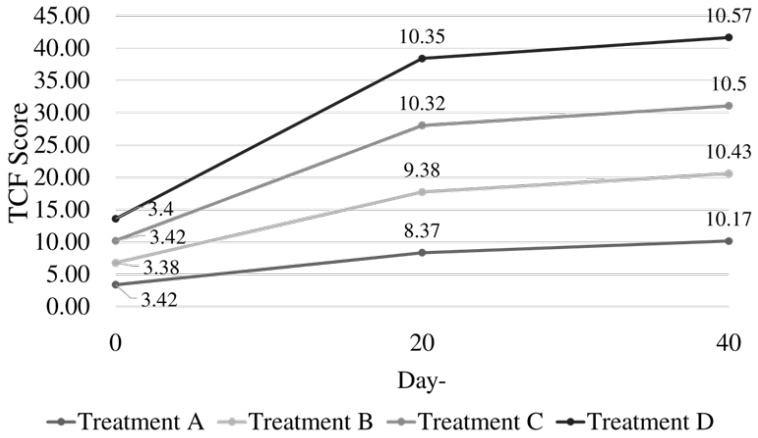

Figure 2. Graph of the average body color quality of comet fish.

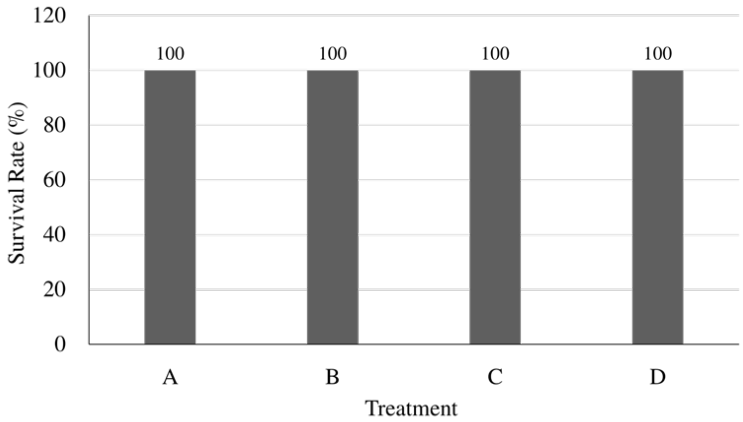

Figure 3. The survival rate of fish based on the treatments. (A) control (no dragon fruit peel powder added); (B) addition of 5% dragon fruit peel powder; (C) addition of 10% dragon fruit peel powder; (D) addition of 15% dragon fruit peel powder.

play a role in enhancing the immune system against disease, as well as reducing stress in fish. These findings are supported by Simamora (2019), whose study reported a 100% survival rate in clownfish *(Amphiprion ocellaris)* fed with diets supplemented with dragon fruit peel powder.

Weight and length growth

The growth of comet fish was also observed during the study. Fish growth is influenced by the quality and quantity of feed as well as the age of the fish. Figure 4 shows the results of the weight growth of the fish, while Figure 5 presents the length growth of the fish according to each treatment. Based on the data presented in Figure 4, the weight growth of comet fish in this study showed fluctuations across all treatments.

However, the graph indicates that the highest weight gain occurred in treatment D, reaching 4.60 grams. Figure 5 shows that feed supplemented with varying doses of dragon fruit peel powder resulted in an increase in the length of comet fish. Treatment A (control) yielded an average length of 5.62 cm, treatment B (5% dragon fruit peel powder) reached 7.46 cm, treatment C (10%) reached 7.36 cm, and treatment D (15%) reached 7.40 cm.

Specific growth rate

The observations showed that the growth of comet fish increased as the amount of dragon fruit peel powder added to the feed increased. The results of the specific growth rate calculations are shown in Figure 6. As it shown in Figure 6, the highest specific growth rate (SGR) value was obtained in treatment C (addition of 10% dragon fruit peel powder), which was 0.934 ± 0.215 gram/day, while the lowest value was

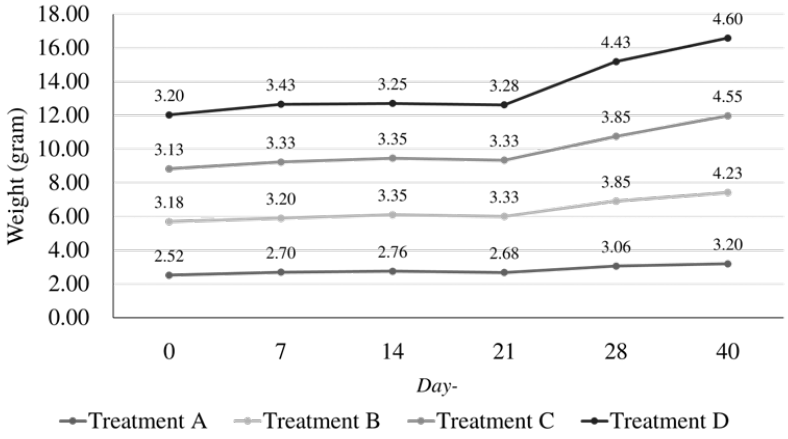

Figure 4. Fish weight growth based on treatments. (A) control (no dragon fruit peel powder added); (B) addition of 5% dragon fruit peel powder; (C) addition of 10% dragon fruit peel powder; (D) addition of 15% dragon fruit peel powder.

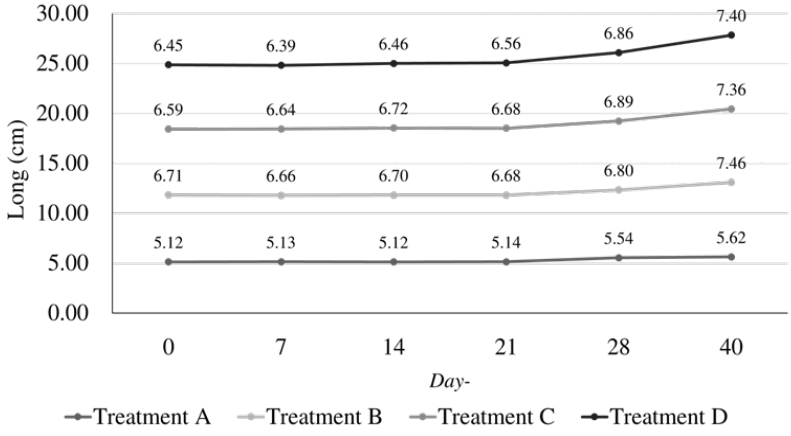

Figure 5. Growth in length of fish. (A) control (no dragon fruit peel powder added); (B) addition of 5% dragon fruit peel powder; (C) addition of 10% dragon fruit peel powder; (D) addition of 15% dragon fruit peel powder.

found in treatment A (no addition of dragon fruit peel powder), which was 0.598 ± 0.367 gram/day. These results indicate that the growth rate increased with the addition of up to 10% dragon fruit peel powder and then decreased when the amount was increased to 15%.

The feed used in this study contained 30-35% protein, at least 3% fat, a maximum of 4% crude fiber, a maximum of 12% ash, and a maximum of 12% moisture. The complete nutritional content of the feed contributed to faster fish growth. However, based on the ANOVA test, there was no significant difference in the specific growth rate among the treatments, which is in line with the statement by Sholihah et al. (2015) that adding carotenoids to ornamental fish feed does not affect fish growth, as the carotenoids are primarily used to enhance color quality rather than growth.

Feed conversion ratio

Table 4 showing the feed conversion ratio (FCR) of comet fish when given feed with added dragon fruit peel powder. As it shown in Table 4, the feed conversion ratio (FCR) values are between 0.09 and 0.17, with treatment C (10% dragon fruit peel powder) showing the lowest FCR of 0.09. This indicates that, for this treatment, only 90 grams of feed are required to produce 1 kg of fish meat, which suggests efficient feed utilization. The order of FCR values from lowest to highest is as follows C (10% of dragon fruit peel powder), D (15% of dragon fruit peel powder), B (5% of dragon fruit peel powder), A (control, no dragon fruit peel powder added). The smaller the feed conversion ratio (FCR) value, the more efficiently the fish are utilizing the feed, allowing more energy to be directed toward growth (Sitio *et al.,* 2017). Other factors that can affect FCR include the nutrient and nutritional content of the feed, as highlighted by Suarjuniarta *et al.* (2021).

Water quality

The results of water quality observations in the rearing containers during the study can be seen in Table 5. The highest pH value obtained during the rearing was 8.38, and the lowest value was 6.4. These values are still within the normal range for comet fish, as stated by Gultom *et al.* (2018). The pH level, whether high or low, affects aquatic life because it influences chemical processes in water. The dissolved oxygen (DO) level in water is very important for aquatic organisms. The

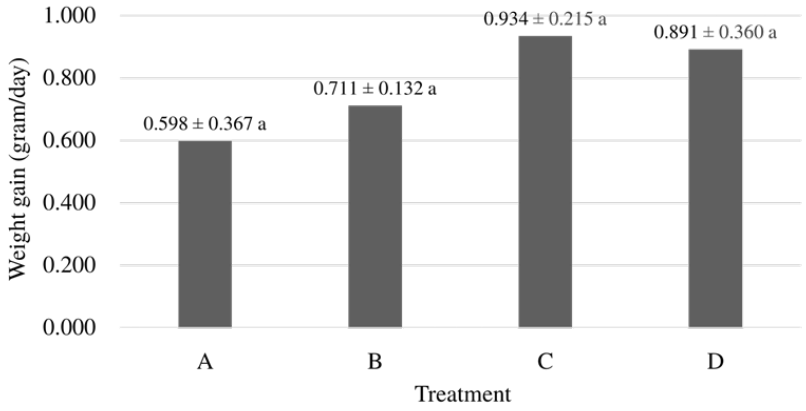

Figure 6. Specific growth rate based on the treatments. (A) control (no dragon fruit peel powder added); (B) addition of 5% dragon fruit peel powder; (C) addition of 10% dragon fruit peel powder; (D) addition of 15% dragon fruit peel powder.

Table 4. Feed conversion ratio based on the treatments.

Treatments	Feed conversion ratio
A (control)	0.17 ± 0.08[a]
B (addition of 5% dragon fruit peel powder)	0.12 ± 0.05[a]
C (addition of 10% dragon fruit peel powder)	0.09 ± 0.03[a]
D (addition of 15% dragon fruit peel powder	0.11 ± 0.06[a]

Note: the values followed by the same lowercase letter do not show significant differences based on the Duncan multiple range test at a 5% error rate.

optimal dissolved oxygen level for comet fish is ≥3 mg/l (BSN, 2019). This is consistent with the observation results, where the dissolved oxygen level during the rearing ranged from 3.35 to 6.7 mg/l.

Discussion

Antioxidant activity analysis was measured using the DPPH method with a UV-Vis spectrophotometer at a maximum wavelength of 517 nm. In this study, methanol compound and dragon fruit peel powder samples were used as comparisons, with measurements taken at five concentrations: 0, 1600, 3200, 4800, 6400, and 8000 ppm. Absorbance was then measured to obtain the % inhibition results (Table 2). Subsequently, regression calculation was performed between % inhibition and quercetin concentration.

The standard curve equation obtained was Y = a + bX, where Y = 0.008x + 2.3313; R^2 = 0.9947. The IC_{50} value was then calculated, yielding a value of 5731.9217 (Table 1). This result indicates that dragon fruit peel powder has low antioxidant activity, as the IC_{50} value is above 250 µg/mL, indicating very low activity. According to Handayani *et al*. (2014), an IC_{50} value < 10 µg/mL is considered very strong, 10-50 µg/mL is strong, 50-100 µg/mL is moderate, and values between 100-250 µg/mL are weak, while values above 250 µg/mL are very low. Based on this, dragon fruit peel powder exhibits low antioxidant activity but still has potential as an antioxidant.

The pigmentation color test on dragon fruit peel powder was carried out using a chromameter. The data obtained were in the form of L*, a*, and b* values. L* refers to lightness or brightness, a* indicates the red color, and b* indicates the yellow color. The higher the L* value, the brighter the sample color (white). If the a* value is higher, the sample color approaches red, and if the b* value is higher, the color moves toward yellow (Lembong & Utama, 2021).

The chroma and hue degree values were then calculated to determine the color range. A chroma value of 26.32 and a hue value of 3.18° were obtained. The higher the chroma value, the higher the carotenoid content, resulting in a brighter color, while a lower hue degree value results in an orange-red color (Sukarman & Hirnawati, 2014). Other natural ingredients that can be used as sources of color pigmentation to improve color in fish include the addition of carrot powder, mangosteen peel powder, and Spirulina powder (Yusniarti *et al.,* 2018; Nurrahma *et al.,* 2018; Andriani *et al.,* 2018). Changes in the brightness of the fish's body color are a key factor in assessing the effectiveness of pigment supplementation (Nur *et al.,* 2020).

The addition of dragon fruit peel powder to the feed has an impact on the improvement of comet fish color quality. The change in brightness of the comet fish's body with the addition of dragon fruit peel powder is more prominent in treatment D. This condition is due to the high carotenoid content in the dragon fruit peel and the fish's ability to absorb the carotenoids in the feed effectively. Color quality is directly proportional to the addition of carotenoids in the feed (Aslianti & Nasukha, 2012). The more feed containing carotenoids, the brighter the color.

Physiologically, fish can produce color variations from feed containing color pigments (Yusniarti *et al.,* 2018). The change in color is caused by the active movement of pigment granules or chromatophores, including xanthophores, erythrophores, and indophores (Huang *et al.,* 2021). Fish can only synthesize black and white pigments, while for other colors such as red, orange, and yellow, fish require supplemental feed containing carotenoids (Andriani, 2022). Each pigment plays an important role in creating

Table 5. Water quality during fish rearing.

Treatments	Average values of water quality		
	Temperature (°C)	pH	DO (mg/l)
A	24.8 – 27.2	6.4 – 8.3	3.4 – 6.7
B	24 – 27.1	6,7 - 8,3	3.35 – 4.4
C	24 – 27.1	6.6 - 8.35	3.45 – 4.39
D	24.8 – 27.1	6.6 – 8.38	3.6 – 4.36
Quality standards	23 – 29*	6 – 8.3	≥3*

Note: *(Gultom *et al.*, 2018).

a unique and attractive color pattern (Andriani *et al.,* 2024). The difference in brightness levels is due to fish having varying absorption rates and the different doses provided in each treatment (Amin *et al.,* 2012).

The process of color change in fish begins with carotenoids (color pigments) in the feed being absorbed and transported through the bloodstream, then stored in adipose tissue. The pigments are then deposited in the chromatophore cells located in the dermis (Melati *et al.,* 2017). Dense body color in fish is caused by the even spread of pigment cells, while pale fish color is caused by pigment cells clustering at the cell core (Meilisza *et al.,* 2021). The increase in color observed in treatment A (control) is due to internal factors such as the aging of the fish. The increase in color is caused by both internal and external factors. Internal factors include age, size, genetics, sex, and the fish's ability to absorb nutrients from the food (Merli *et al.,* 2017), while the increase in color in treatments B, C, and D is due to the addition of dragon fruit peel powder.

The more dragon fruit peel powder added to the feed, the higher the color value in the comet fish's head. Comet fish show improved coloration with the addition of mangosteen peel powder (Yusniarti *et al.,* 2018). Color brightness in fish increased on day 20. This is in line with statements that fish experience color improvement by the third week. Research shows that color changes in fish begin in the first ten days, although they are not very noticeable. This is because the fish are still adapting to the type of feed provided. During the second ten days, all treatments show color improvement, and the color improvement is clearly visible after forty days of observation (Lestari *et al.,* 2020; Meilisza *et al.,* 2021).

A healthy fish body will absorb color pigments from the feed more easily. If the fish are unhealthy, they focus on maintaining their health through the feed provided, so the fish need to be in good health to proceed to the next stage, which is the absorption of feed that can influence the fish's body color quality (Meilisza, 2023). The survival rate of comet fish with the addition of dragon fruit peel powder did not have a negative impact on the fish's mortality, possibly because the carotenoid content in the dragon fruit peel is not harmful to the fish's health. Dragon fruit peel also contains polyphenols as antioxidants, which play a role in the immune system against diseases and protect fish cells and tissues from damage caused by free radicals (Sukhovskaya *et al.,* 2023). In addition, antioxidants in the dragon fruit peel can reduce stress in the fish. This is supported by research showing that the addition of dragon fruit peel powder to clownfish resulted in a 100% survival rate (Efianda *et al.,* 2020).

The growth results in the length and weight of comet fish with the addition of dragon fruit peel powder did not show a significant effect; however, descriptively, it can be seen that the average growth in weight and length of the comet fish that received the addition of the powder experienced an increase. The relationship between the growth of length and weight in comet fish is positively allometric, meaning the weight grows faster than the length of the fish (Ramses *et al.,* 2020). Dragon fruit peel contains protein and fat, which can support the growth of comet fish. Therefore, dragon fruit peel powder is safe to add to the feed for comet fish (Kalidupa *et al.,* 2018).

CONCLUSION

Based on the results of the study, it can be concluded that the addition of 15% dragon fruit peel powder into the feed (treatment D) can improve the color of the comet fish body with an average value of 10.57. Meanwhile, the best results for specific growth rate and feed conversion ratio were found in treatment C (addition of 10% dragon fruit peel powder), with values of 0.934 g/day and 0.09, respectively.

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