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FEED MANIPULATION TO ENHANCE COLOR BRIGHTNESS IN ORNAMENTAL FISH: LITERATURE REVIEW

Manipulasi Pakan untuk Meningkatkan Kecerahan Warna Pada Ikan Hias: Studi Literatur

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ABSTRACT

The main attraction of ornamental fish is their color. However, the color of ornamental fish can deteriorate in quality, which will ultimately affect their selling price. One of the efforts to enhance the brightness of ornamental fish colors is through the supplementation of carotenoids derived from natural ingredients into the feed. The aim of this research is to explore various natural carotenoid sources supplemented through feed, which have been proven effective in enhancing the color brightness of various ornamental fish species. Data collection was conducted by reviewing various scientific literature relevant to the chosen research topic.The literature was sourced from the Google Scholar and ScienceDirect databases.The results show that several plants such as Water Hyacinth (Eichhornia crassipes), Indigofera (Indigofera zollingeriana), Kepok Banana (Musa balbisiana colla), Red Bell Pepper (Capsicum annuum L.), Sesban (Sesbania grandiflora), Melinjo (Gnetom gnemon), Yellow Pumpkin (Cucurbita moscheta durch), Moringa (Moringa oliefera), Marigold (Tagetes erecta), Purple Sweet Potato (Ipomoea batatas L.), Beet (Beta vulgaris), Tomato (Solanum lycopersicum), Carrot (Daucus carota), Papaya (Carica papaya), Red Dragon Fruit (Hylocereus polyrhizus), and Red Spinach (Amaranthus tricolor L) have been proven effective in enhancing the color brightness of several ornamental fish species.This is due to the carotenoid content such as α-carotene, β-carotene, lycopene, lutein, and zeaxanthin present in each of the plants.The utilization of carotenoids sourced from natural materials is expected to reduce production costs in ornamental fish farming.

Keywords: Carotenoids, Color, Feed, Ornamental Fish

ABSTRAK

Daya tarik utama dari ikan hias adalah warnanya. Akan tetapi warna pada ikan hias bisa mengalami penurunan kualitas yang pada akhirnya akan mempengaruhi harga jual. Salah satu upaya untuk meningkatkan kecerahan warna pada ikan hias adalah melalui suplementasi karotenoid yang berasal dari bahan – bahan alami ke dalam pakan. Tujuan dari penelitian ini

adalah untuk mengeksplorasi berbagai sumber karotenoid alami yang disuplementasikan melalui pakan dan sudah terbukti efektif dalam meningkatkan kecerahan warna berbagai spesies ikan hias. Pengumpulan data dilakukan dengan menelusuri berbagai literatur ilmiah yang relevan dengan topik penelitian yang diambil. Literatur tersebut bersumber dari database *Google scholar* dan *ScienceDirect*. Hasilnya diketahui bahwa beberapa tanaman seperti Eceng gondok (*Eichhornia crassipes*), Indigofera (*Indigofera zollingeriana*), Pisang kepok (*Musa balbisiana colla)*, Paprika merah (*Capsicum annuum* L.), Turi (*Sesbania grandiflora*), Melinjo (*Gnetom gnemon*), Labu kuning (*Cucurbita moscheta durch*), Kelor (*Moringa oliefera*), Marigold (*Tagetes erecta*), Ubi jalar ungu (*Ipomoea batatas* L), Bit (*Beta vulgaris*), Tomat (*Solanum lycopersicum)*, Wortel (*Daucus carota*), Pepaya (*Carica papaya*), Buah naga merah (*Hylocereus polyrhizus*), dan Bayam merah (*Amaranthus tricolor* L) terbukti efektif dalam meningkatkan kecerahan warna pada beberapa spesies ikan hias. Hal ini disebabkan oleh kandungan karotenoid seperti α-karoten, β-karoten, likopen, lutein, dan zeaxanthin yang ada pada masing – masing tanaman. Pemanfaatan karotenoid yang bersumber dari bahan – bahan alami diharapkan mampu menekan biaya produksi dalam budidaya ikan hias.

Kata Kunci: Karotenoid, Warna, Pakan, Ikan Hias

INTRODUCTION

The trend of keeping ornamental fish has become popular in recent years. This is related to the benefits felt when keeping ornamental fish, one of which is that it can relieve stress or anxiety. The results of a study by Sarman & Gunay (2023) found that children who interacted with Goldfish for three days had lower levels of anxiety and fear and better mental and emotional health compared to those who did not. Some of the species that are favorites of ornamental fish lovers are *Poecilia reticulata, Cyprinus carpio, Carassius auratus, Betta* sp. The main parameter that is the attraction of ornamental fish is their color because it will affect the selling price (Bianco et al., 2021). The high selling value of koi fish is largely determined by the sharpness and beauty of their color (Suprastyani et al., 2017). Because of its faded color, the price of local goldfish is usually cheaper than imported goldfish (Fitriana et al., 2013). *Carassius auratus*, which has a yellow and reddish orange color, has a high selling price (Khairunnisa et al., 2020). The problem faced by ornamental fish farmers is the less attractive color quality of the fish, which has an impact on the selling price (Haq et al., 2022; Mukti et al., 2023). Several efforts have been made to improve the color quality of ornamental fish through genetic improvement, environmental engineering, and feed engineering (Setiawan et al., 2024; Aprilio et al., 2024; Oktaviani et al., 2024).

Pigmentation in fish is caused by chromatophore cells (pigments) located in the epidermis layer (Uly et al., 2017; Juliana, 2023; Faulia and Farastuti, 2024). The main components that form pigments, especially yellow-orange and red-orange, are carotenoids (Ningsi et al., 2018; Adrian et al., 2021; Hidayah et al., 2022; Sari et al., 2022). However, fish cannot synthesize carotenoids de novo, so it is necessary to supplement various types of natural ingredients containing carotenoids in feed (Madiara et al., 2019; Prariska et al., 2022). The high concentration of carotenoids in the fish body is caused by the high concentration of carotenoids supplemented into the feed (Tania et al., 2018, Mukti et al., 2023). Some sources of carotenoids include tomatoes, carrots, lettuce, red spinach, celery, cucumber, sweet potatoes, broccoli, kale, pumpkin, blueberries, plums, mangoes, watermelons, kiwis, red peppers, beans, cabbage, melons, parsley, peanuts, soybeans, sunflowers, and green vegetables (Gebregziabher et al., 2023).

Research on the effect of natural carotenoid supplementation in feed on the intensity and brightness of fish color has been widely conducted. The color quality of *Puntigrus tetrazona* increased after being given feed enriched with red spinach flour (Koncara et al., 2018). A dose

of 1.5 grams of *Spirulina* sp. flour/100 grams of feed has been proven to be effective in increasing the brightness of the color of Ambon snakehead fish in 45 days of maintenance (Ismail et al., 2020). Giving 30 grams of shrimp shell flour in feed can increase the brightness of the color of comet fish (Efianda et al., 2020). Pumpkin flour supplementation can significantly increase the color brightness of *Amphipriion ocellaris* (Sartikawati et al., 2020). The color of the goldfish (*Carassius auratus*) increased by 28.53 RGB after its feed was added with 50 ml of purple sweet potato juice (Wulandari et al., 2023). Based on the results of these studies, it is known that carotenoid supplementation through feed has been proven effective in increasing color brightness in ornamental fish. The purpose of this study was to explore various sources of natural carotenoids that are supplemented through feed and have been proven effective in increasing the color brightness of various ornamental fish species. This information can certainly help ornamental fish farmers to reduce their dependence on synthetic carotenoid sources which are not only unsafe for fish but also have a negative impact on the aquatic environment.

METHODS

This research is qualitative research with descriptive analysis techniques with literature studies. Literature studies are data collection techniques by understanding and studying hypotheses from various references related to the research to be conducted (Adlini et al., 2022). The research was conducted from February to March 2025. The data collected and analyzed were secondary data consisting of 82 national journals, 1 international journal, and 2 proceedings related to natural carotenoid supplementation in feed to increase color brightness in ornamental fish. All of them are sourced from the Google Scholar and ScienceDirect databases by entering the search for "carotenoids in feed", "color in ornamental fish", "carotenoids in ornamental fish". Literature searches using a laptop connected to a wifi network. Each literature is then collected and read to determine the parts needed in compiling this article.

RESULTS

The results of previous studies using natural ingredients as sources of carotenoids in feed are presented in Table 1.

Table 1. Effect of Supplementation of Various Types of Natural Ingredients in Feed on the Brightness of Ornamental Fish Color

Natural Ingredients	Types of Carotenoids	Best Dose	Types of Fish	Maintenance Time	Color Brightness	Reference
Water hyacinth (*Eichhornia crassipes*)	β-carotene and Xanthophyll	300 g of water hyacinth flour/kg of feed	*Carassius auratus*	30 days	The highest color change was in treatment D at 1.65 (dark red)	Viomalini & Nugrahini, 2020; Syahrizal *et al.*, 2017
Indigo (*Indigofera zollingeriana*)	β-carotene and Xanthophyll	15% *I. zollingeriana* shoot flour	*Puntigrus tetrazone*	40 days	The greatest value of increasing the color quality of Sumatran fish was obtained in treatment D, namely by adding 15% *I. zollingeriana*	Kustiningsih & Retnawati, 2020; Pratama *et al.*, 2019
Kepok banana (*Musa balbisiana colla*)	β-carotene	15% banana peel powder	*Amphipriion ocellaris*	30 days	Produces the highest color brightness with a value of 26.30	Winara *et al.*, 2023; Faturrahman *et al.*, 2020

Natural Ingredients	Types of Carotenoids	Best Dose	Types of Fish	Maintenance Time	Color Brightness	Reference
Red pepper (*Capsicum annuum L.*)	β-carotene	5% paprika juice	*Poecilia reticulata*	30 days	This dose affects the sharpness of the color of guppy fish, which is indicated by the appearance of new colors, namely blue and purple	Warsi & Erlila, 2017; Apriasih *et al.*, 2021
Turi (*Sesbania grandiflora*)	β-carotene	100 ppm (70 g of pigeon pea flour)	*Melanotaenia parva*	40 days	This concentration provides the most optimal percentage and density of orange color	Witoyo *et al.*, 2024; Meilisza *et al.*, 2021
Melinjo (*Gnetom gnemon*)	β-carotene	4.5 ml/100 g of feed	*Carassius auratus*	40 days	This dose caused an increase in the RGB color of the fish at the location below the dorsal fin by 12.77	Suci, 2015; Basorudin *et al.*, 2022
Summer squash (*Cucurbita moscheta durch*)	β-carotene	30 ml/100 g of feed	*Betta* sp.	60 days	The brightness level of the color in betta fish increases by 55%	Lismawati *et al.*, 2021; Sari *et al.*, 2022
Moringa (Moringa *oliefera*)	β-carotene	45 ml moringa leaf extract/100 kg feed	*Betta* sp.	30 days	This dose produces the highest level of color brightness in betta fish	Tahir *et al.*, 2016; Takdir *et al.*, 2022
Marigold (*Tagetes erecta*)	α-carotene, β-carotene, lutein, and zeaxanthin	1.5% marigold flower flour	*Poecillia reticulata*	50 days	This dose caused an increase in carotenoid content of 13.80 µmol/g	Kurniati, 2021; Habmarani *et al.*, 2023
Purple sweet potato (*Ipomoea batatas* L)	β-carotene	15% purple sweet potato flour	*Cyprinus carpio*	90 days	This dose produces a Toca Color 6 value with a difference of 0.53, which is the highest color brightness level	Fauziah *et al.*, 2015; Wahyu & Chadijah, 2023
Bit (*Beta vulgaris*)	β-carotene	7%/100 g of feed	*Carassius auratus*	30 days	There was a color change with an optimal RGB value of 42.67	Dewi, 2019; Khalil *et al.*, 2023
Tomatoes (*Solanum lycopersicum)*	Zeaxanthin	75% (75 mL tomato extract + 10 mL binder + 15 g commercial feed)	*Amphiprion biaculeatus*	1 month	The dose has a significant effect on the percentage of red value	Sulistyowati *et al.*, 2021; Kilmanun *et al.*, 2024
Summer squash (*Cucurbita moschata*) and Tomatoes (*Solanum lycopersicum* L)	β-carotene and Zeaxanthin	5% pumpkin extract + 7.5% tomato extract	*Poecilia sphenops*	45 days	Increases color brightness in molly fish by 7.4%	Lismawati *et al.*, 2021; Sulistyowati *et al.*, 2021; Audina *et al.*, 2024
Carrot (*Daucus carota*)	β-carotene	15% carrot flour/500 g of feed	*Cyprinus carpio*	30 days	Obtaining the results of the number of chromatophore cells of 938 cells, the difference in hue value was (4.40±1.39°)°	Agustina *et al.*, 2019; Dwiastuti *et al.*, 2024
Papaya (*Carica papaya*)	β-carotene	10 g of papaya seed flour	*Carassius auratus*	30 days	The dose had a significant effect on color quality, with a	Idrus *et al.*, 2021; Faulia *et al.*, 2024

Natural Ingredients	Types of Carotenoids	Best Dose	Types of Fish	Maintenance Time	Color Brightness	Reference
					color scoring value of 24.93	
Red dragon fruit (*Hylocereus polyrhizus*)	β-carotene and lycopene	2,500 mg/kg feed	*Cyprinus carpio*	60 days	This dose is able to increase the color gradation, namely with a score of 10 (red gradation) and 11 (black gradation)	Aryanta, 2022; Haerawati & Sambara, 2024
Red spinach (*Amaranthus tricolor* L)	β-carotene	20% red spinach extract	*Carassius auratus*	45 days	Molly fish experienced an increase in color brightness of 4.22	Pajrita *et al.*, 2023; Fitriani *et al.*, 2024

DISCUSSION

The color of fish is not only an aesthetic aspect, but also plays an important role in their survival and social interactions. The color of fish can be an indicator to assess the health status of fish. When fish are stressed, the color of the fish's body will tend to pale (Rahmawati et al., 2016). The color pattern on the fish's body can also be used to determine abnormalities because it is a genetic trait inherited from its parents (Afini et al., 2014). The colors of coral fish are a form of camouflage against the background of their environment, which aims to avoid enemies or to approach prey (Costa, 2009). Related to the reproductive aspect, color is one of the secondary sexual characteristics in fish to distinguish gender. Male guppy fish (*Poecilia reticulata*) have very bright body and fin color patterns (Nugroho et al., 2021). Male guppy fish have a jet-black body color that is slightly bluish, while female guppy fish have a less bright and slightly transparent color (Azrar et al., 2023).

Several factors that affect pigmentation in fish include water quality, disease, and carotenoid content in feed (Rahmawan et al., 2022; Hamjah et al., 2024; Khairunnisa et al., 2020). Carotenoid supplementation in feed to improve the color of ornamental fish has been widely carried out. Based on the data in table 1, it is known that supplementation of natural ingredients such as water hyacinth, indigofera, banana kepok, red pepper, turi, melinjo, moringa, marigold, purple sweet potato, beetroot, pumpkin, tomato, carrot, papaya, red dragon fruit, and red spinach in feed has been proven effective in increasing color brightness in several ornamental fish species. This is due to the carotenoid content in each plant which includes α-carotene, β-carotene, lutein, zeaxanthin, and lycopene. Carotenoids are organic pigments found in the chloroplasts and chromoplasts of plants, algae, bacteria, and fungi that function as photoprotectors and light-collecting accessory pigments (Sun et al., 2017; Hendriyani et al., 2018; Hanani et al., 2020). Carotenoids consist of two main groups, namely carotenes (α-carotene, β-carotene, and lycopene) and xanthophylls (lutein, zeaxanthin, astaxanthin, canthaxanthin). The advantages of natural carotenoids are that they are non-toxic, easily decomposed, environmentally friendly and more effective in increasing the brightness of color in fish (Barus et al., 2014; Pujilestari, 2015). In addition, by using natural carotenoid sources, farmers can reduce production costs (Suprastyani et al., 2017, Rizky et al., 2023).

The effectiveness of carotenoids in increasing the brightness of fish color is influenced by the type, structure, and dose of carotenoids. Astaxanthin (red), canthaxanthin (reddish orange), lutein (yellow), zeaxanthin (yellow orange), and tunaxanthin (yellow) are types of carotenoids used for aquatic animals (Nainggolan et al., 2024; Amin et al., 2012; Tania et al., 2018). β-carotene is an orange-yellow pigment, while lycopene is a pigment that can provide red color. Xanthophyll is an oxygen carotene, can provide orange-yellow color. Lutein is also a very common carotenoid, more greenish-yellowish in color (Pujilestari, 2015). β-carotene can increase the red color in fish (Mukti et al., 2023). There is a decrease in hue value in koi

fish given a carotenoid source in the form of carrot flour (high in β-carotene) in the feed so that the resulting orange color becomes dark orange or towards red (Dwiastuti et al., 2024).

In addition to the type, the structure and stability of carotenoids from each ingredient can cause differences in the brightness of the fish color. Carotenoid pigments have aliphatic and alicyclic structures (Subamia et al., 2010). The difference between the two lies in the number of conjugated double bonds, where the aliphatic structure has 11 conjugated double bonds while the alicyclic structure only consists of 9-10 conjugated double bonds. The more conjugated double bonds, the color tends to shift to the red spectrum with a more concentrated intensity (dark red). Carotenoids that have an aliphatic structure are lycopene, while β-carotene is alicyclic. The main obstacle when using carotenoids derived from natural ingredients such as plants is their less stability when compared to synthetic carotenoids. The conjugated double bonds of β-carotene give it a pro-oxidant character, resulting in it being very easily oxidized. This oxidation process can be triggered by several factors, including temperature, light, oxygen, and metal catalysts (Agustiarini et al., 2016). At a temperature of 900C, there is a decrease in the content of β-carotene pigment, causing damage to the chromophore group in the β-carotene structure and then rapid bleaching or fading of the β-carotene compound (Oktora et al., 2016).

The dose of carotenoids will affect the increase in the number of chromatophore cells (Malini et al., 2018). Research by Rahman et al. (2021) stated that giving *Spirulina* sp. flour as much as 9%/kg of feed produced the highest number of chromatophore cells in goldfish. Too low a dose of carotenoids causes the pigmentation process through the dermis and epidermis tissues to be inhibited. This is thought to be because carotenoids have not been able to stimulate fish chromatophore cells to produce pigments to increase color brightness (Dahlia et al., 2023). Too high a dose of carotenoids will not affect the increase in color brightness of fish. This is in accordance with the results of research by Simbolon et al., (2021) which explains that the use of 50 ml of papaya fruit extract/kg of feed (the highest dose) does not provide a higher color increase in goldfish. This is thought to be because the number of carotenoids given exceeds the number of carotenoids needed by goldfish, thus affecting the adsorption process. Each type of fish has different abilities in utilizing and absorbing carotenoids from feed (Nur et al., 2020 in Salsabila et al., 2024). Carotenoids that are not adsorbed will then be excreted through feces (Amin et al., 2012; Putri et al., 2024).

The length of time the fish are kept has a significant effect on the absorption of carotenoids, which are important pigments for improving the color and quality of fish (Said et al., 2005). The increase in color intensity in comet fish shows a positive correlation with the duration of maintenance. Color changes began to be observed significantly on the 15th day of the total maintenance period of 45 days. This happens because the carotenoids in the feed have been absorbed and accumulated, which causes the red color on the body of the comet fish to become sharper (Indarti et al., 2012). Research by Haerawati & Sambara (2024) shows that the level of carotenoid accumulation in the body of fish varies depending on the duration of maintenance and the dose of carotenoids given. Where the highest carotenoid levels of koi fish occurred when entering the sixth week at a dose of 2000 mg/kg feed, which was 0.737 ppm. This also shows that the rate of carotenoid absorption varies in each species and size of fish. Fish characteristics including species, size, age, and gender also affect carotenoid absorption. Male fish look brighter due to the accumulation of carotenoids in the epidermis of the skin. Unlike male fish, carotenoids in female fish are stored in the gonads to maintain the quality of their gonads (Storebaken & No, 1992 in Said et al., 2005). Larger guppies also require higher carotenoid content (Hidayah et al., 2022). *Scleropages formosus* has a silvery body color when it is one and two years old, but then changes to yellowish when it is three years old (Masfah et al., 2018).

Increasing carotenoid levels in the body of fish not only affect color but also the growth, health, and reproduction of fish. *Channa marulioides* fed with a mixture of shrimp head flour containing β-carotene experienced an absolute weight growth of 10.36 grams and an absolute length of 9.79 cm (Warastuti et al., 2022). Supplementation of *S. platensis* at a dose of 6% in feed has been shown to increase the resistance of zebrafish (*Danio rerio*) placed in environmental stress in the form of low pH (5±0.1), with a survival rate at the end of the maintenance period of 63.33±5.77% (Agung et al., 2021). The color produced due to carotenoid supplementation in feed will increase the attraction between fish of different sexes so that it will have an impact on the success of fish reproduction (Jatiswara et al., 2020).

CONCLUSION

Supplementation of natural ingredients such as Water hyacinth (*Eichhornia crassipes*), Indigofera (*Indigofera zollingeriana*), Kepok banana (*Musa balbisiana colla*), Red pepper (*Capsicum annuum* L.), Turi (*Sesbania grandiflora*), Melinjo (*Gnetom gnemon*), Yellow pumpkin (*Cucurbita moscheta durch*), Moringa (*Moringa oliefera*), Marigold (*Tagetes erecta*), Purple sweet potato (*Ipomoea batatas* L), Beetroot (*Beta vulgaris*), Tomato (*Solanum lycopersicum*), Carrot (*Daucus carota*), Papaya (*Carica papaya*), Red dragon fruit (*Hylocereus polyrhizus*), and Red spinach (*Amaranthus tricolor* L) has been proven effective in increasing the brightness of colors in several ornamental fish species including *Carassius auratus, Puntigrus tetrazone, Amphipriion ocellaris, Poecilia reticulata, Melanotaenia parva*, and *Cyprinus carpio*. This is due to the carotenoid content such as α-carotene, β-carotene, lycopene, lutein, and zeaxanthin found in each plant.

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