Color Brightness and Growth Levels of Goldfish (*Carassius auratus*) Reared with Different Light Spectrums

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Abstract

Carassius auratus is one of the potential ornamental freshwater fish in Indonesia. The potential of this fish increases along with the dominance of the colors produced during cultivation. We have demonstrated to treat differences in the light spectrum to increase the brightness of the colors. Completely randomized design with 5 treatments and 4 replications as the design i.e., (P1) negative control with no LED, (P2) positive control using white LED light and a room light intensity, (P3) red LED, (P4) green LED, and (P5) blue LED. We reported that the red LED was the light spectrum that produced the best treatment to increase the color brightness and growth of goldfish. The brightness level of the color in the P3 treatment was 63,04% as measured by Adobe Photoshop; using the M-TCF method, it was 8,94% body color, 9,37% dorsal fin, and 9,31% tail fin. Meanwhile, the best specific growth rate were found in P5 followed by P3 treatment in a row of $5,33 \pm 0,66^{b}$, $3,46 \pm 0,57^{ab}$, respectively. The red color spectrum produced the best pigmentation but the blue color spectrum was the best for the growth of *C. auratus*.

Keywords: biodiversity, color brightness, goldfish, growth, light spectrum

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INTRODUCTION

Ornamental fish is a potential fishery commodity in Indonesia. Besides being able to be cultivated on a large or small scale, capital turnover is also relatively fast (Rifai *et al*., 2022). Currently, freshwater ornamental fish like goldfish (*Carassius auratus*) are the commodities most in demand by the public (Sollid, 2005).

C. auratus is in great demand because of its attractive body shape and color. The good category of fish for this species is the brightness of the color, normal size, and body. The brightness of the color is influenced by chromatophore cells, which are located in the epidermal layer. The increase in color brightness in goldfish is directly proportional to the number of chromatophore cells (Panjaitan *et al*., 2016).

However, this fish has a slow growth rate (Erlangga *et al*., 2019). Factors that affect the brightness of the color of goldfish include genetics, pigment, water quality, feed, and lighting (Wulandari *et al*., 2019). Efforts to increase the brightness of the color and growth of goldfish are made by manipulating the light spectrum using light-emitting diodes (LEDs) (Aras *et al*., 2016). Because they are efficient, inexpensive, of higher durability, and environmentally friendly (Migaud *et al*., 2007).

Artificial light in cultivation, through the right combination of spectrum, intensity, and photoperiod, produces higher pigment concentrations in the chromatophore cells (Tume *et al*., 2009). In addition, the appropriate light spectrum can increase the ability of fish to recognize feed, thereby increasing growth (Hafiz *et al*., 2020). We conducted this study to evaluate the effect of different light spectra on the color brightness and growth of goldfish.

MATERIALS AND METHODS

Samples

A total of 200 fish measuring 6,43 ± 0,05 cm (2,23 ± 1,09 g.ind^{-1}) were reared in 20 aquariums (30 × 30 × 40 cm^3) for 45 days. M-TCF paper was used to determine the color of the sample. An aerator as oxygen supply for each treatment and equipped with LED lights. Each treatment received four different colors, i.e., white, red, green, and blue. A digital lux meter (LX1010b) was used to measure the intensity of light. Then, a digital scales and millimeter blocks were used to determine the fish weight and length. For in situ water quality monitoring, pH, temperature, and daily measurements were performed. In addition, during the study, in situ measurements of dissolved oxygen (Multiparameter^{TM}), ammonia, nitrate, and nitrite (APHA 2017 titration method) were performed every week during evaluation.

Study Design

This study used a complete randomized design (CRD) with five treatments and four replications i.e., (P1) negative control with no LED light and a room light intensity of 135 lux, (P2) positive control using white LED light and a room light intensity of 1,567 lux, (P3) red LED light and a room light intensity of 1,567 lux, (P4) green LED light and a room light intensity of 1088 lux, and (P5) blue LED light and a room light intensity of 1181 lux. The treatment was performed in August – September 2021 at the Anatomy Laboratory, School of Health and Life Sciences, Universitas Airlangga.

Site Preparation

The aquarium was dried which was cleaned using disinfectant. Furthermore, it was filled using 10 liters of water and aerated for 24 hours. LED lights in white, red, green, and blue were used. Meanwhile, the M-TCF paper used was a modified paper that is made in ten different colors ranging from light orange to dark orange.

Pisciculture

Fish were reared for 45 days at a stocking density of one fish per liter. The initial color, brightness, weight, and length of a burned fish. *C. auratus* was reared in an aquarium with various light spectrum treatments and a 12-hour photoperiod. Furthermore, the feeding method used was ad satiation, with the frequency of feeding three times per day at 08.00, 12.00, and 15.00. The water management system works by siphoning up to 10% of the water every three days to remove the organic content. Water quality was measured once a week by adjusting the aerator and dissolved oxygen to maintain a constant level. Temperature, dissolved oxygen, pH, and ammonia are all used to assess air quality (Fikri *et al*., 2022).

Fish Color Observation

Color observations were performed using two methods: the M-TCF method and Adobe Photoshop. The M-TCF method was used by 5 healthy and no colorblind panelists to take measurements. The M-TCF method was measured at three locations: the body, the dorsal fin, and the tail fin. A stereo microscope (Olympus CX23) with a light intensity of 100-6,400 lux was used to capture visual color observations with a camera (the Cannon EOS 60D). The Red, Green, and Blue (RGB) color gradation conversion method found in the Adobe Photoshop CS6 application was then used to calculate the percentage of red color.

Growth Parameters

Absolute weight measurement was carried out using the formula according to (Erlangga *et al*., 2019). Furthermore, the calculation of the specific growth rate according to (Mulfizar *et al*., 2012). $\Delta W = W_t - W_0$, where ΔW stands for absolute weight (g), W_t for final weight (g), and W_0 for initial weight (g). $Sgr = \frac{(Wt - Wo)}{t} \times 100\%$, where Sgr stands for specific growth rate (%), W_t for final weight (g), W_o for initial weight (g), t for rearing periode (days).

Data Analysis

The influence of altering the light spectrum on the color brightness and growth of goldfish was analyzed using one-factor ANOVA ($p < 0,05$), and the Duncan multiple range test with a

95% confidence interval was used for further analysis.

RESULTS AND DISCUSSION

There were variations in the luminosity of goldfish reared under various light spectra (Table 1). The treatment with red LED light (P3) had the greatest influence on the color intensity of the goldfish. This is likely because the red light spectrum makes it simpler for goldfish to locate their food, allowing them to absorb the feed's carotene content to its fullest extent. In addition, it is believed that the red light spectrum can mitigate damage to the astaxanthin content in fish chromatophore cells caused by exposure to ultraviolet light and prevent the hydrolysis of carotenoids in the body. Red and blue light can encourage fish to consume the supplied food (Volpato *et al*., 2013). Astaxanthin hydrolyzes into derivatives consisting of a single fatty acid and forms monoesters (Tume *et al*., 2009), which can cause chromatophore cells to fade in fish raised in aquatic environments with bright illumination. The use of the red light spectrum can also increase the number of chromatophore cells, thereby intensifying the color of Botia fish seeds (Aras *et al*., 2016). *C. auratus* have an average of 423 chromatophore cells per body (Matsui *et al*., 2016). The number of chromatophore cells in the scales of goldfish ranges from 161 to 514 (Aras *et al*., 2016).

Chromatophore cells are color cells whose function is to color the fish's body (Tume *et al*., 2009). Each species of fish has chromatophore cells with various combinations and proportions in order to adapt to its environment. The nervous system and the hormones epinephrine and acetylcholine control fish pigmentation (Lai *et al*., 2020). Epinephrine can cause fish to lose their color because it causes pigment granules to congregate in the center of the cell. In the meantime, acetylcholine is a hormone secreted by the nervous system into the muscles, causing melanin to spread and the fish's body pigment to darken (Slominski *et al*., 2004). Pigment granules that are dispersed can allow cells to absorb the light spectrum to its utmost extent, thereby enhancing the brightness and clarity of the scales' color (Indarti *et al*., 2012).

In contrast, the P5 treatment (blue LED light) had the greatest impact on the specific growth rate of *C. auratus* (Table 2). *C. auratus* are pelagic fish that actively pursue food in bright light conditions or diurnal (Harini *et al*., 2019). According to Syam and Satria (2009), pelagic fish can receive 75% blue-green light with a wavelength spectrum of 450–570 nm. In contrast, *C. auratus* is a diurnal fish with a cone cell shape that dominates the sense of sight to absorb light from 440 to 500 nanometers (Hoar and Randall, 1971; Sale, 1991). This study's findings are consistent with those of Gunawan (2017), who discovered that gourami, a diurnal fish raised with the addition of blue LED lighting, experienced an increase in specific growth of 0,2%. The mechanism by which the blue light spectrum affects growth is that light entering the retina of a fish's eye stimulates red-green cone cells and excites yellow-blue ganglion cells, causing them to emit a blue signal (Razak, 2017). The incoming light spectrum is then transmitted to the hypothalamus, where it stimulates the anterior and intermediate pituitaries to secrete melanocyte-stimulating hormone (MSH), adrenocorticotropin hormone (ACTH), and thyroid hormone. Some of these hormones, particularly thyroid hormone, can stimulate the production of growth hormone (Hardiansyah and Lamid, 2022). TSH, which is secreted by the anterior pituitary gland, controls thyroid hormone secretion. Thyroid hormone enhances the activity of growth hormone and its secretion (Gunawan and Suraya, 2019).

Moreover, the light spectrum reflected in the eye's retina stimulates the Arylamine N-acetyltransferase (AANAT) gene. Two AANAT genes exist in the body: ANAAT 1, which is expressed in the retina of the eye, and ANAAT 2, which is located in the pineal gland. The two AANATs are able to catalyze the production of N-acetylserotonin and hydroxy indole O-methyltransferase and convert N-acetylserotonin to melatonin. Through the hypothalamus and pineal tract, the retinal and pineal gland responses are transmitted to the ventral diencephalon. In addition, light information can reach the pituitary

Table 1. Brightness of goldfish reared with different light spectra

Treatment	Color intensity (%)			
	Adobe photoshop	M-TCF		
		Body color	Dorsal fin	Caudal fin
P1	53,51 ± 2,64[a]	6,93 ± 0,94[a]	7,93 ± 0,85[a]	7,81 ± 1,34[a]
P2	55,07 ± 2,18[a]	8,18 ± 0,23[ab]	8,75 ± 0,45[ab]	9,31 ± 0,51[b]
P3	63,03 ± 3,56[b]	8,93 ± 1,16[b]	9,37 ± 0,52[b]	9,31 ± 0,89[b]
P4	54,70 ± 2,78[a]	7,50 ± 0,54[a]	8,06 ± 0,42[a]	9,62 ± 0,32[b]
P5	54,18 ± 1,19[a]	7,50 ± 0,93[a]	8,37 ± 0,85[ab]	8,68 ± 0,55[ab]

Different superscript in the same column indicates significant differences ($p < 0,05$).

Table 2. Growth of goldfish reared with different light spectra

Parameters	P1	P2	P3	P4	P5
Initial weight ($g.ind^{-1}$)	2,79 ± 0,29	2,65 ± 0,09	2,64 ± 0,18	2,58 ± 0,26	2,70 ± 0,13
Final weight ($g.ind^{-1}$)	3,89 ± 0,29	4,04 ± 0,13	3,76 ± 0,32	3,86 ± 0,13	5,11 ± 0,17
Initial length ($cm.ind^{-1}$)	6,59 ± 0,20	6,33 ± 0,16	6,32 ± 0,23	6,44 ± 0,29	6,46 ± 0,28
Final lenght ($cm.ind^{-1}$)	7,97 ± 0,32	7,99 ± 0,46	8,01 ± 0,39	7,99 ± 0,15	9,15 ± 0,35
Total lenght ($cm.ind^{-1}$)	1,38 ± 0,11[a]	1,65 ± 0,35[a]	1,69 ± 0,25[a]	1,55 ± 0,271[a]	2,68 ± 0,18[b]
Total weight ($g.ind^{-1}$)	1,08 ± 0,16[a]	1,38 ± 0,19[a]	1,81 ± 0,26[ab]	1,27 ± 0,277[a]	2,40 ± 0,29[b]
Sgr (%)	2,42 ± 0,37[a]	3,07 ± 0,42[a]	3,46 ± 0,57[ab]	2,82 ± 0,616[a]	5,33 ± 0,66[b]

Different superscript in the same column indicates significant differences ($p < 0,05$).

gland directly via melatonin (Bjornson and Jornsson, 2004). It is believed that this melatonin secretion promotes the proliferation of goldfish. Melatonin can directly accelerate fish growth and regulate fish appetite. The spectrum of light that fish receive influences the secretion of melatonin. According to Kelber (2016) study, seabass fish exposed to the blue light spectrum are capable of producing more melatonin, which has a positive effect on growth rates. The red light spectrum is the best light spectrum for increasing the color intensity of goldfish, according to the results of the study, when compared to the blue light spectrum as the best treatment for increasing the color intensity and growth of goldfish. Although the growth of goldfish in the spectrum of red light was less than that of blue light, it still differed from the growth of goldfish in the absence of light, white light, and green light. While blue light only influences growth, it has no significant effect on skin color brightness. According to Harini *et al*. (2009), the red light spectrum can aid fish in recognizing their food, allowing for optimal nutrient absorption.

CONCLUSION

In conclusion, the light spectrum has an effect on the color intensity and growth of goldfish. The consequence of rearing goldfish in the red light spectrum was an increase in color intensity and significant growth. Although the highest growth rate was obtained from fish under the blue light spectrum treatment, the best attractive color was obtained from the treatment with the red light spectrum. The attractive color was a must in ornamental fish.

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