The effects of LED light spectrum manipulation on growth and color performance of giant gourami Osphronemus gouramy Lacepede Padang strain

Manipulasi spektrum cahaya lampu LED terhadap kinerja pertumbuhan dan warna ikan gurami strain Padang Osphronemus gouramy Lacepede

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ABSTRACT

This study aimed to evaluate the effect of light spectrum on growth and color performance of giant giant gourami Padang strain. The experiment used a completed randomized design (RAL) with four light emitting diode (LED) treatments in different emission spectra (white, red, green, and blue) at 550 Lux intensity, compared to the control treatment (light room with white tubular lamp at 50 Lux intensity). The irradiation was carried out for 12 hours of photoperiod. The fish used had the total length of 82.90 ± 4.2 mm and body weight of 9.87 ± 0.99 g. The highest growth performance was found in blue LED treatment with the specific growth rate of 2.73 ± 0.2% and feed efficiency of 86.26 ± 2.71%. The best color performance was found in red LED treatment with the RGB ratio of 44.57 ± 0.62% in dorsal fin, 38.41 ± 1.36% in pectoral fins, and 45.33 ± 2.25% in anal fin with the chromatophore cell concentration at 1.973 ± 58 cells/mm².

Keywords : Osphronemus gouramy, blue LED, spectrum, chromatophore, light

ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi pengaruh spektrum cahaya terhadap kinerja pertumbuhan dan warna ikan gurami strain Padang. Rancangan penelitian yang digunakan adalah rancangan acak lengkap (RAL) dengan 4 perlakuan cahaya lampu light emitting diodes (LED) yang memiliki spektrum panjang gelombang berbeda (putih, merah, hijau dan biru) intensitas 550 Lux dan kontrol (cahaya ruang berasal dari lampu tubular putih intensitas 50 Lux). Penyinaran dilakukan selama 12 jam mengikuti fotoperiod. Ikan uji yang digunakan memiliki panjang total 82.90 ± 4.2 mm, dengan bobot 9.87 ± 0.99 g. Kinerja pertumbuhan terbaik terdapat pada perlakuan LED biru dengan laju pertumbuhan spesifik sebesar 2.73 ± 0.2% dan efisiensi pakan sebesar 86.26 ± 2.71%. Performa warna terbaik terdapat pada perlakuan LED merah dengan rasio warna merah pada RGB bagian dorsal sebesar 44.57 ± 0.62%, sirip pektoral sebesar 38.41 ± 1.36%, dan sirip anal sebesar 45.33 ± 2.25% dengan jumlah sel kromatofor sebanyak 1.973 sel/mm².

Kata kunci : Osphronemus gouramy, LED biru, spektrum, kromatofor, cahaya
INTRODUCTION

Giant gourami Osphronemus gourami Lacepede is a freshwater fish originated from Indonesia and known as popular high economical consumed fish. Several giant gourami strains that have been cultured by the community include Soang, Jepang, Paris, Bastar, Bluesafir, Batanghari, and Padang strains (Nugroho et al., 2013). In general, giant gourami fish has dark body color and less attractive which can only be utilized as a consumed fish. In contrast with other strains, the giant gourami Padang strain has a bright reddish color utilized not only as a consumed fish, but also attracting the fish collectors to maintain it as an ornamental fish. The giant gourami fish population in its natural habitat is currently decreasing due to land degradation and environmental pollution based on the low number of giant gourami catch in Indonesia at 4,580 ton in 2015 (FAO, 2017). Efforts to increase the availability through culture activity could significantly produce an increased production in 2010 at 56,888 ton which increased by 113,396 ton in 2015 (FAO, 2017). These were the highest values compared to other countries that reached 97.24% of world’s production in 2015 (FAO, 2017), although having a low survival rate at 50% (Fitriadi et al., 2014; Pratama et al., 2018) and slow growth rate. Survival rate is affected by several factors, namely sex, inheritance, age, reproduction, and disease resistance. Moreover, water quality, stocking density, and feed composition also contribute to the fish survival rate level (Nugroho et al., 2015; Budiana & Rahardja, 2018). The giant gourami breeding network multilocation test results in 2012 in Jambi, South Sumatera, and Bengkulu proved that the giant gourami Padang strain obtained the growth rate at 30% lower than the Batanghari strain (Nugroho et al., 2013). Giant gourami Padang strain is also vulnerable to stress on a fluctuate environmental condition. A fluctuate environmental condition triggers a stress condition that occurs due to metabolic energy reallocation to homeostatic improvement as supposed to be used for growth and reproduction (Pamungkas, 2012; Akbar et al., 2012).

An applicative technology to overcome the giant gourami production is an environmental manipulation such as light through spectrum manipulation or wavelength (λ) with the light emitting diode/LED. Villamizar et al. (2009) reported that the blue LED could increase the total length of European seabass larvae. The green LED was also reported to increase the specific growth rate of clown loach at 2.35%, while red LED could increase its total chromatophore cells (Aras, 2016; Nurdin, 2016). This study aimed to analyze and evaluate the environmental manipulation through LED spectrum expected to increase the growth rate and total pigment cells related to the color performance of giant gourami Padang strain.

MATERIALS AND METHODS

Period and location

This study was performed experimentally by a completely randomized design with five LED lamp spectrum treatments and three replications for each treatment, namely four LED lamp spectrum treatments at 550 Lux intensity based on Villamizar et al. (2009) in different wavelengths: white (LP = λ peak at 465 and 550 nm), red (LM = λ peak at 465 nm), green (LH = λ peak at 525 nm), and blue (LB = λ peak at 450 nm), compared to white colored-TL lamp (K = room light control) at 50 Lux intensity.

Experimental design

This study was performed experimentally by a completely randomized design with five LED lamp spectrum treatments and three replications for each treatment, namely four LED lamp spectrum treatments at 550 Lux intensity based on Villamizar et al. (2009) in different wavelengths: white (LP = λ peak at 465 and 550 nm), red (LM = λ peak at 465 nm), green (LH = λ peak at 525 nm), and blue (LB = λ peak at 450 nm), compared to white colored-TL lamp (K = room light control) at 50 Lux intensity.

Procedures

The giant gourami Padang strain seeds were obtained from the giant gourami culturist in Parung, West Java. The average of fish weight used was 9.87 ± 0.99 g and the average total length of 82.90 ± 4.2 mm. The fish test stocked in each experimental unit was 15 seeds (400 seeds/m³ stocking density). The containers used in this study were 15 glass aquaria at 45×32×45 cm³ size. The treatment on each aquarium was placed randomly. To minimize the outside light, the base, wall, and upper part of the aquaria was covered with a mulch plastic. Then, aquaria were
filled with 36 L water at 3 g/L salinity level. Each aquarium was equipped with aeration and internal filtration. The LED lamp was installed at certain height following the light intensity requirement at 550 Lux (Aras 2016). The LED lamp used was six white-colored CE 101 LED lamp bulbs at 12 volts. At the socket, a timer was installed, therefore the lamp was automatically turned on at 07.00 GMT +7 and turned off at 19.00 GMT +7 (Shin, 2012; Aras, 2016). The test fish were maintained for 60 days and fed with a commercial feed (38% protein) with apparent satiation three times a day at 07.00, 13.00, and 19.00 GMT +7.

**Parameters and data analysis**

Data related to the physiological response containing oxygen consumption level, blood glucose level, total protein serum, and blood triglycerides were measured in the beginning, middle, and end of the treatment period. Meanwhile, stamina test was measured at the end of treatment period. The fish length and weight were measured once in 15 days. The growth performance data containing specific growth rate, absolute growth rate, length growth rate, feed efficiency, length and weight coefficient of variance, and survival rate, was measured at the end of treatment period. The color parameters observed were red color ratio percentage on RGB ratio and the total chromatophore cells were observed in the beginning and end of the treatment period. Water quality data containing temperature, pH, dissolved oxygen, and salinity were measured each day, while TAN (total ammonia nitrogen) and alkalinity levels were measured once in two weeks.

The evaluated parameters in this study is presented in Table 1. Data were tabulated using a Microsoft Excel 2013. A statistical test used an analysis of variance (ANOVA) with SPSS 20.0 was performed on the growth performance and color performance data, which was continued using the Duncan’s test at 95% confidence level. The water quality data was analyzed descriptively.

**RESULTS AND DISCUSSIONS**

**Hasil**

**Growth performance**

The influence of LED spectrum on the growth performance of giant gourami Padang strain is presented on Table 2. The ANOVA results showed that the LED spectrum had an insignificant effect on the survival rate (P>0.05), but having a significant effect (P<0.05) on the specific growth rate (SGR), absolute growth rate (AGR), length growth rate (LGR), and feed efficiency (FE). The highest FE value was obtained from

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Methods or measurement tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival rate (SR)</td>
<td>%</td>
<td>Sari <em>et al.</em> (2017); Francisca &amp; Muhsoni (2021)</td>
</tr>
<tr>
<td>Specific growth rate (SGR)</td>
<td>%</td>
<td>Schulz <em>et al.</em> (2005)</td>
</tr>
<tr>
<td>Absolute growth rate (AGR)</td>
<td>g/fish/day</td>
<td>Effendie (1979)</td>
</tr>
<tr>
<td>Length growth rate (LGR)</td>
<td>mm</td>
<td>NRC (1983)</td>
</tr>
<tr>
<td>Feed efficiency (FE)</td>
<td>%</td>
<td>Takeuchi (1988)</td>
</tr>
<tr>
<td>Length coefficient of variance (CV)</td>
<td>%</td>
<td>Steel and Torie (1991)</td>
</tr>
</tbody>
</table>

**B. Color performance**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Methods or measurement tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red color ratio on RGB ratio (dorsal fin, pectoral fins, and anal fin)</td>
<td>%</td>
<td>Adobe photoshop CS4</td>
</tr>
<tr>
<td>Total chromatophore cells</td>
<td>cells/mm²</td>
<td>Aras (2015)</td>
</tr>
</tbody>
</table>

**C. Water quality**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Methods or measurement tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>Thermometer and DO meter</td>
</tr>
<tr>
<td>Dissolved oxygen</td>
<td>mg/L</td>
<td>DO meter</td>
</tr>
<tr>
<td>pH</td>
<td>-</td>
<td>pH meter</td>
</tr>
<tr>
<td>Salinity</td>
<td>g/L</td>
<td>Rephractometer</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>mg/L</td>
<td>Titration</td>
</tr>
<tr>
<td>Total ammonia nitrogen (TAN)</td>
<td>mg/L</td>
<td>Spectrophotometer</td>
</tr>
</tbody>
</table>
the LB treatment at 86.26 ± 2.71% which was significantly different from other treatments (P<0.05). The best growth performance was obtained from the blue LED treatment (SGR, AGR, LGR) that was significantly different from other treatments (P<0.05).

The weight and length growth rate indicate a positive trend during maintenance period as presented in Figure 1. All treatments on the first 30 days was in the lag phase, and exponentially increased until the 60-th day. At the end of maintenance period, the highest average weight and length growth of giant gourami Padang strain was obtained from the LB treatment at 50.26 g and 127.25 mm, followed by the LP treatment at 39.94 g and 127.85 mm, LH treatment at 39.91 g and 127.25 mm, LM treatment at 34.58 g and 121.79 mm, and K treatment at 35.65 g and 121.75 mm.

Based on Figure 2, the LB treatment obtained the lowest CV value at 7.59 ± 0.59%, while the LM treatment obtained the highest CV value. The CV value on the LB treatment was significantly different from the LM (18.58 ± 1.21%), K (17.77 ± 5.71%), and LH (17.62 ± 2.11%) treatments, but was insignificantly different from the LP treatment (12.55 ± 2.56%).

![Graph A: Weight growth](image)

![Graph B: Length growth](image)

Figure 1. The average (A) Weight growth; and (B) length growth of giant gourami Padang strain Osphronemus gouramy Lac.

Table 2. Growth performance of giant gourami Padang strain Osphronemus gouramy Lac.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>K</th>
<th>LP</th>
<th>LM</th>
<th>LH</th>
<th>LB</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR (%)</td>
<td>73.33 ± 6.67a</td>
<td>82.22 ± 3.85a</td>
<td>82.22 ± 13.88a</td>
<td>71.11 ± 7.70a</td>
<td>88.89 ± 10.18a</td>
</tr>
<tr>
<td>SGR (%)</td>
<td>2.18 ± 0.14a</td>
<td>2.36 ± 0.12a</td>
<td>2.11 ± 0.15a</td>
<td>2.11 ± 0.15a</td>
<td>2.73 ± 0.20a</td>
</tr>
<tr>
<td>AGR (g/fish/day)</td>
<td>0.43 ± 0.05b</td>
<td>0.50 ± 0.06c</td>
<td>0.41 ± 0.05a</td>
<td>0.50 ± 0.08a</td>
<td>0.67 ± 0.10b</td>
</tr>
<tr>
<td>LGR (mm)</td>
<td>39.86 ± 3.36a</td>
<td>45.69 ± 3.91a</td>
<td>38.83 ± 2.54a</td>
<td>44.06 ± 5.25a</td>
<td>54.25 ± 4.41b</td>
</tr>
<tr>
<td>FE (%)</td>
<td>66.28 ± 2.36c</td>
<td>68.94 ± 2.38b</td>
<td>56.48 ± 1.69c</td>
<td>68.97 ± 0.83b</td>
<td>86.26 ± 2.71c</td>
</tr>
</tbody>
</table>

*aDifferent superscript letters on the same line show a significant difference (Duncan’s test; P<0.05). Values are presented in the average and standard deviation values. K= room light control; LP = white LED; LM = red LED; LH = green LED; LB = blue LED.*
Color quality

The ANOVA results showed that the LED spectrum treatments could significantly influence the red color ratio percentage on the RGB ratio as presented in Table 3. Samples from dorsal fin, pectoral fins, and anal fin obtained the highest values on the red LED treatment that was also significantly different from other treatments (P<0.05).

The increased color performance based on the increased total chromatophore cells on the dorsal fin is presented in Figure 3. The ANOVA results showed that the LED spectrum significantly influence the total chromatophore cells with the highest value was obtained from the red LED treatment at 1.973 cells/mm² which was significantly different from other treatments (P<0.05).

Increased color performance based on the red percentage in the RGB ratio and total chromatophore cells on all treatments indicates a chromatophore cell movement to certain body parts that are exposed to the light (presented in Figure 4), whereas the LM and LB treatments were observed to have chromatophore cells concentrated in a certain area, contradictory to other treatments which had distributed chromatophore cells.

Table 3. The red ratio percentage on the RGB ratio in three body parts of giant gourami Padang strain Osphronemus gouramy Lac.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dorsal fin</th>
<th>Pectoral fins</th>
<th>Anal fin</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>37.35 ± 2.26&lt;sup&gt;c&lt;/sup&gt;</td>
<td>34.27 ± 1.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.65 ± 3.28&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>K</td>
<td>37.90 ± 0.78&lt;sup&gt;c&lt;/sup&gt;</td>
<td>34.30 ± 0.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.65 ± 0.52&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>LP</td>
<td>39.17 ± 1.18&lt;sup&gt;c&lt;/sup&gt;</td>
<td>35.33 ± 0.30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>38.28 ± 0.71&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>LM</td>
<td>44.57 ± 0.62&lt;sup&gt;c&lt;/sup&gt;</td>
<td>38.41 ± 1.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>45.33 ± 2.25&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>LH</td>
<td>36.99 ± 0.94&lt;sup&gt;c&lt;/sup&gt;</td>
<td>34.20 ± 0.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37.11 ± 0.91&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>LB</td>
<td>36.71 ± 0.81&lt;sup&gt;c&lt;/sup&gt;</td>
<td>34.65 ± 0.70&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37.15 ± 0.71&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>c</sup>Different superscript letters on the same line show a significant difference (Duncan’s test; P<0.05). Values are presented in the average and standard deviation values. K= (control) room light; LP = white LED; LM = red LED; LH = green LED; LB = blue LED.
Water quality

The water quality measurement results for 60 days of maintenance is presented in Table 4. The temperature in all treatments was among 29.5–32.5 °C. The oxygen concentration was generally among 3.3–4.8 mg/L. The pH values in all treatment were among 5.17–8.72. The salinity value showed a relatively stable and uniform value at 3 %. The highest alkalinity level was obtained from the LP treatment at 210.21–270.27 mg/L, while the lowest alkalinity level was obtained from the LM treatment at 180.18–280.28 mg/L. The TAN values in all treatments were among 0.094–0.57 mg/L.

Discussions

The best growth performance results were from the blue LED treatment which was also found in Illamizar et al. (2009). The blue LED light spectrum increased the total length of seabass larvae at kakap 15.4 ± 0.6 mm and weight of 21.6 ± 2.02 mg, which was significantly different from other color spectrum treatments. This condition was caused as giant gourami was more capable of detecting the blue light with short wavelength following its natural habitat. Also, it was also observed from the results presented in the table that the LB treatment was significantly different from other treatments.

Light is extremely important for most organisms. The light spectrum penetration to the waters is less than to the land due to selective absorption by natural water components. Therefore, a spectral distribution from the light to the eyes from an object in the water depends on the object distance to the eyes, and the object detection depends on the light from the object relative against the background that can be seen to produce the best visual with a maximum wavelength (λ max) that can be absorbed as a correction result from the light wavelength that penetrates the water (Loew & Lythgoe, 1978).

In diurnal fish, a visual capability is the main sensor for feeding activity and protection strategy, as photoreceptor cells in fish have been proved the color discrimination theory in fish (Ayyubi et al., 2019; Escobar-Camacho et al., 2019). The photoreceptor cells contain two types, namely cones and rods. Cones are cone cells responsible for bright vision and color differential, while rods are rod cells responsible for low vision and bright level information provider (Vinberg et al., 2018; Zang & Neuhaus, 2021). Several freshwater fish species are included in a blue-sensitive cone that only have one cone cell with dominated rod cells (Nabiu et al., 2018). These fish are extremely sensitive on short blue light wavelength (460 nm), which can absorb blue color more optimally than other colors (Loew & Lythgoe, 1978). This condition also occurred on the giant gourami as this study object. A deeper study regarding light influence on fish endocrinial system found that there was an association between blue light (λ 434–477 nm) and increased melatonin level production in seabass fish. Shin et al. (2012) emphasized that a higher GH-RNA expression level in fish pituitary of clownfish Amphiprion clarkia after being injected with melatonin on blue and green light treatments than on red light treatment. This was thought was melatonin stimulated the GH secretion as a growth promoter.

Feed efficiency (FE) is a successive indicator for feed utilization. The higher feed efficiency value, the less feed requirement to produce one kilogram of fish flesh as the feed can utilized optimally for growth. Rahmawati et al. (2016) stated light could influence the feeding activity and stimulate the feed consumption level in fish. This study also concluded that light exposure at night could decrease the feed conversion ratio. Low feed conversion ratio means that the fish can utilize the feed more efficiently and suppress the feed cost. In addition, Setiawati et al. (2013) clarified that a good feed efficiency could provide a greater energy availability which implicated on the increased energy level used for growth support. Rahmawati et al. (2016) showed that the 24-hour light produced the lowest feed conversion level at 1.45 ± 0.12, followed by the highest absolute weight growth, growth rate, and survival rate of tambaqui Colossoma macropomum. Elsbaay (2013) showed that the use of blue spectrum on Nile tilapia obtained the lowest feed conversion at 1.04 ± 0.01 and FE value at 96.15% as significantly different from other treatments. Difference among the treatments were occurred due to the stimuli acceptance and wavelength tolerable differences.

Different LED lamp spectra affected the length coefficient of variance (CV) in test fish (P<0.05). The CV values were variate in each treatment as thought due to associated with high stocking density applied in this study which was five times higher than the traditional culture (SNI, 2000), besides the giant gourami character as a territorial fish. The higher stocking density, the narrower movement space, resulting in space and feed competition that leads to domination and
hierarchical structure in the community. Several individuals showed a faster adaptability which could grow faster, while other individuals were less adaptable that led to stress condition and slow growth (Folnari et al., 2017; Sihite et al., 2020).

Light intensity, spectrum, light duration, and photoperiod can be organized to control the fish growth (Heydarnejad et al., 2013; Lopez-Betancur et al., 2020). The lowest CV value was obtained from the blue LED treatment which indicates that the blue light can suppress the stress level in giant gourami Padang strain, therefore the energy gained from the feed can be utilized optimally for growth. This condition was emphasized by Ninwichian et al. (2018) who stated that the snakeskin gourami Trichogaster pectoralis maintained in a blue tank produced a better growth, a lower feed conversion, a lower cortisol level, and a lower plasma glucose level. This condition was also reported by Ebrahimi (2011) who studied the application of blue tank for guppy Poecilia reticulata growth. Kawamura et al. (2017) also proved that the blue light could inhibit stress on red sea bream juvenile due to low plasma glucose level in blue light treatment, compared to red, green, and white light treatments.

Color quality measurement using the RGB model is more efficient and easier, besides can potentially provide an early detection on the feed impact in color quality and fish phenotypic differences (Novita et al., 2019). The RGB model can presented as a three-dimensional space that describes the exposed colors based on three main colors (Rulaningtyas et al., 2015; Prabowo et al., 2018). This model is an additive model as all color spectra from 380 nm to 780 nm can be formed by mixing the three primary colors in different proportions to produce more than 16 million colors (Lustini et al., 2019; Rabhani et al., 2021). Chromatophore cells increased along with the fish age based on the low total chromatophore cells at the beginning of maintenance period (699 cells/mm$^2$) that increase at the end of maintenance period in all treatments. In teleost fish, chromatophore cells are originated from multipotential pigment cell precursors produced by neural crest cell part formed during embryogenesis (Parichy & Spiewak, 2015; Petratou et al., 2021). Chromatophores are responsible for providing the skin color in various species. Lately, there are six chromatophore cells known to be available in fish, namely melanophore for black or chocolate pigmentation, xanthophore for yellow pigmentation, erythrophore for red pigmentation, leucophore for white pigmentation, iridophore for metallic pigmentation associated with color change, and cyanophore for blue pigmentation (Cal et al., 2017; Djurdjević et al., 2019; Luo et al., 2021).

Figure 4 presents the concentrated chromatophore cells in a certain area on the LM and LB treatment. In contrast, other treatments present distributed chromatophore cells. This condition may be caused by the chromatophore cells that have motor protein as movement tool (Salmon et al., 2019). Chromatophore cells are

Figure 4. Histological condition of chromatophore cell distribution in giant gourami Padang strain. (a) Fish before treatment; (b) K= room light control; (c) LP = white LED; (d) LM = red LED; (e) LH = green LED; and (f) LB = blue LED.
extremely sensitive on a certain light wavelength. Oshima and Yokozeki (1999) proved that erythrophore was very sensitive against either longer wavelength (550-600 nm) or shorter wavelength (400-440 nm). In these wavelengths, erythrophore cells were aggregated, contradictory in the 470-530 nm wavelength as the erythrophore cells tended to be dispersed.

In this study, the blue LED obtained a wavelength of 400–470 nm with the peak wavelength at 450 nm, and red LED was in 550–700 nm with the peak wavelength at 625 nm, while green LED was in 470–575 nm with the peak wavelength at 525 nm, and white LED was in 400-700 nm with two peak wavelengths at 465 and 550 nm. The range of LED lamp wavelength used was nearly closed with the range value by Oshima and Yokozeki (1999), which was thought as the increased total chromatophore cells on each observation field in the LM and LB treatments was due to chromatophore cell aggregation, contradictory with LH, LP, and K treatments that obtained low total chromatophore cells due to chromatophore cell dispersion. The chromatophore cell aggregation and dispersion can be directly caused by light exposure (primary response) or nerve and endocrinal mechanisms (secondary response). In the first case, chromatophores react as independent receptors and effectors, transmitting the light energy in the pigment migration mechanism process or guanine crystal simultaneous movement which causes color change in the integument.

In general, all treatment media had a normal temperature level at 25–30°C (SNI, 2000). The dissolved oxygen level based on the measurement results was in the tolerable limit by the giant gourami. Although the temperature almost reached a temperature of 33°C at the beginning of maintenance period, the giant gourami could still tolerate it, following Pratama et al. (2018) who reported that the temperature used for maintenance was among 28–32°C. The dissolved oxygen level in the maintenance media were in the suggested tolerable limit at 4 mg/L (Riza et al., 2015), but not becoming a limiting factor for giant gourami. Giant gourami can live in low dissolved oxygen level (Akbar et al., 2013; Jumaidi et al., 2017).

The pH value in all treatments were in an optimal pH value range at 6.5–8.5 (SNI, 2000). Salinity was remained at 3 g/L each day following Marda et al. (2015) to maintain an isosmotic condition between fish body and environment, therefore the energy release for osmoregulation can be minimized. The alkalinity level in all treatments were in a suggested range limit at 50–400 mg/L and the TAN value was generally in a normal range recommended by Wahyuningsih and Gitarama (2020) which was less than 1.5 mg/L. The use of internal filter, syphonization activity performed every day, water exchange, and frequent water quality measurement could maintain the water quality level in an optimal range, which produced the water as maintenance medium in this study was in a qualified condition for optimal growth support of the test fish.

CONCLUSIONS

Environmental manipulation with light spectra can improve the growth and color performance of giant gourami Padang strain. The best growth performance was obtained from the blue LED treatment with the peak $\lambda$ of 470 nm based on the SGR, AGR, LGR, PE, and CV values. The best color performance was obtained from the red LED treatment with the peak $\lambda$ of 625 nm based on the red color percentage on RGB ratio and total chromatophore cells.

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