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Increased Productivity of Eggs, FCR, and IOFC from Alabio Ducks through Addition of Artificial Light Ahemeral Method Using the Combination of the Intensity and Color of Monochromatic LED Light

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Abstract

Light illumination, both color and intensity is one of the environmental factors that play an important role in regulating animal biorhythms. The use of artificial light in poultry produces very diverse responses, especially in metabolism, reproduction, and behavior. The purpose of this study was to determine the increase in egg productivity, feed convertion ratio (FCR) and income over feed cost (IOFC) of Alabio ducks through the addition of artificial light using the ahemeral method through a combination of intensity and color of monochromatic LED light. The research method uses a completely randomized factorial design of 4×3 with 3 replications. The first factor is the color of light (W) consisting of 4 levels including W1 (yellow), W2 (red), W3 (blue), W4 (green), and the second factor is light intensity (T) consisting of 3 levels including T1 (10 lux), T2 (15 lux) and T3 (20 lux). Nutritional content of crude protein (CP) 18%, metabolic energy (ME) 2800 kcal. kg^{-1}. The variables observed were egg production, total egg weight, feed consumption, FCR and IOFC. The length of study and measurement of duck egg production is 4 weeks. The results showed that in the 4 weeks of observation the best treatment was a combination of blue light treatment with a light intensity of 15 lux (W3T2), with the highest egg production achievement of 22.40 ± 4.5 $eggs.duck^{-1}$, the total egg weight achievement was 1373, 12 ± 16.5 $g.duck^{-1}$, feed consumption of 810.12 ± 13.5 $g.duck^{-1}$, FCR value of 4.13 ± 1.3 and IOFC of 29,405.39 ± 333, 1 $Rp.duck^{-1}$. The conclusion of this study is the color of blue light with an intensity of 15 lux (W3T2) can increase the productivity of Alabio duck eggs and IOFC obtained.

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Introduction

The position of Alabio ducks is very important for the people in South Kalimantan because of their dependence on the egg products from the ducks. The contribution of eggs from Alabio ducks contributes more than 50% to the entire production of poultry eggs. As a cheap source of animal protein, demand for products from Alabio ducks continues to increase and even cross to other provinces in Indonesia, even to neighboring countries such as Malaysia, Brunei and not even rumored to Japan. Increased productivity of alabio duck eggs should be pursued so that the current total population of around 4.23 million in 2018 can meet high demand (BPS South Kalimantan, 2019). Genetic improvement has been carried out since 2010 by offices and centers, so other technological touches need to be adopted to be more productive and profitable (Biyatmoko, 2016).

One effort that can be done is through the adoption of artificial light, through the addition of light at night to increase the length of the day. Light is important because it is directly related to egg production. Color and light intensity are the most critical factors of all environmental factors because they are able to stimulate several gonagotropin hormones that control reproduction. Light intensity, light color and photoperiodicity (irradiation length) have important effects on egg production activities (Liu *et al.*, 2015). The hypothalamus will develop with a positive triger of light stimuli. The light will emit electromagnetic waves which stimulate the ducks to bluff hypothalamic activity. Color is defined as the wavelength of light that stimulates the retina of the eye to produce changes in poultry behavior such as activity, aggressiveness and eating behavior (Svobodova *et al.*, 2015). Meanwhile, sufficient light intensity is required for the occurrence of releasing reproductive hormones such as FSH, LH as well as the synthesis and secretion of estradiol so as to guarantee the number of functional (mature) ovarian follicles and guarantee sustainable egg production (Liu *et al.*, 2015). According to Shabiha *et al.* (2013) and Svobodova *et al.* (2015), intensities that support poultry egg production range from 10 - 20 lux. To increase production requires a certain wavelength so the wavelength of each color of light that is given will determine the response to the production of certain poultry eggs (Olanrewaju *et al.*, 2012).

Monochromatic light is a type of visible light with a single wavelength frequency and the distance between wavelengths is not too large. The electromagnetic spectrum of monochromatic light has a single color based on its wavelength, namely red (630-760 nm), orange (590-630 nm), yellow (570-590 nm), green (500-570 nm), blue (450-70 nm) 500 nm), and purple (400-450 nm) (Elert, 2008). Kasiyati (2018) said that the successful use of poultry irradiation with light emitting diode (LED) lamps as a source of light is mostly done on modern farms, because it provides advantages in electrical energy efficiency, color emission is more stable, brighter, longer life (long life), and can reduce the humidity of the cage. Artificial light is not only a source of illumination in modern poultry farming but also plays a role in the reproduction response and production of poultry. The study of several colors of light is important because it is possible to cause different responses from production variables.

The purpose of this study was to determine the increase in egg production, total egg weight, feed consumption, FCR and income over feed cost (IOFC) Alabio Ducks through the addition of artificial light using the ahemeral method through a combination of intensity and color of monochromatic LED light.

Material and methods

The study was carried out in poultry cages where measurements of egg production and research observations were carried out for four weeks.

The research material uses Alabio Ducks so that there are 180 ducks, using laying ducks aged 7 months after entering the egg production cycle. The nutritional content of the experimental rations prepared iso protein and iso energy including crude protein (CP) 18%, Metabolizable Energy (ME) 2800 kcal. kg^{-1}, SK 6%, Calcium 2.5%, and Phosphorus (P) 1.5% using the

Win Feed program version 2.8. Drinking water is given to ducks on an adlibitum basis.

The experimental design used a completely randomized 4 × 3 factorial pattern design with 3 replications which consisted of 5 layer ducks for each repetition. The research treatment consisted of 2 factors, where the first factor was the color of the light (W) consisting of 4 levels namely W1 (yellow), W2 (red), W3 (blue), W4 (green), and the second factor namely Light intensity (T) consisting of 3 the standards are T1 (10 lux), T2 (15 lux) and T3 (20 lux). Additional light is given six hours with day length of 28 hours consisting of daylight 18 hours of light and 10 hours of dark is an application with the ahemeral method. Variables observed were egg production, total egg weight ($g.duck^{-1}$), feed consumption ($g.duck^{-1}$), Feed Convertion Ratio (FCR), and Income Over Feed Cost (IOFC). Data obtained in this study were analyzed by variance analysis (Anova). If the analysis of variance is significantly different, it will be continued with the mean difference test using the Duncan Multiple Range Test (DMRT) at the 5% and 1% significance levels (Steel and Torrie, 1993).

Results and discussion

The results of research observations on the effect of the addition of artificial light ahemeral method using a combination of intensity and color of monochromatic LED light on egg production, total egg weight, feed consumption, and FCR of Alabio ducks are presented in Table 1.

Table 1. Average egg production, feed consumption and feed conversion ratio (FCR) of Alabio Ducks for four weeks.

Treatment	Egg Production ($egg.duck^{-1}$)	Total Egg Weight ($g.duck^{-1}$)	Feed Consumption ($g.duck^{-1}$)	FCR
W1T1 (yellow color, 10 lux)	13,06 ± 4,6^{a}	800,98 ± 11,6^{a}	736,88 ± 10,6^{a}	6,44 ± 1,1^{a}
W1T2 (yellow color, 15 lux)	13,06 ± 5,7^{a}	800,98 ± 13,7^{a}	727,72 ± 9,7^{a}	6,36 ± 1,3^{a}
W1T3 (yellow color, 20 lux)	14,93 ± 4,3^{b}	915,41 ± 14,3^{b}	802,92 ± 14,3^{b}	6,14 ± 1,1^{b}
W2T1 (red color, 10 lux)	16,80 ± 6,1^{b}	1029,84 ± 16,1^{b}	863,56 ± 12,1^{b}	5,87 ± 1,5^{b}
W2T2 (red color, 15 lux)	16,80 ± 5,4^{b}	1029,84 ± 15,4^{b}	857,68 ± 12,4^{b}	5,83 ± 2,2^{b}
W2T3 (red color, 20 lux)	18,66 ± 4,6^{c}	1144,26 ± 17,6^{c}	871,24 ± 15,6^{c}	5,33 ± 1,7^{c}
W3T1 (blue color, 10 lux)	18,66 ± 4,2^{c}	1144,26 ± 15,2^{c}	874,52 ± 12,2^{c}	5,35 ± 1,6^{c}
W3T2 (blue color, 15 lux)	22,40 ± 4,5^{e}	1373,12 ± 16,5^{e}	810,12 ± 13,5^{e}	4,13 ± 1,3^{e}
W3T3 (blue color, 20 lux)	20,53 ± 3,9^{d}	1258,69 ± 12,9^{d}	830,72 ± 11,9^{d}	4,62 ± 1,2^{d}
W4T1 (green color, 10 lux)	18,66 ± 4,9^{c}	1144,26 ± 14,9^{c}	885,96 ± 12,9^{c}	5,42 ± 1,6^{c}
W4T2 (green color, 15 lux)	20,53 ± 5,5^{d}	1258,69 ± 13,5^{d}	819,92 ± 12,5^{d}	4,56 ± 1,9^{d}
W4T3 (green color, 20 lux)	20,53 ± 6,1^{d}	1258,69 ± 14,1^{d}	827,12 ± 14,1^{d}	4,60 ± 1,9^{d}

Note: Figures followed by different superscripts in the same column show significantly different ($p < 0.05$);W: Light color; T: Light intensity; FCR: Feed Convertion Ratio.

Egg Production and Total Weight

At the egg production level (egg) in Table 1, it was seen that during the four weeks of observation, the combination of light color with light intensity of monochromatic LED lamps with an ahemeral method significantly affected the amount of egg production in eggs ($p < 0.05$), where treatment with the combination of blue light color and light intensity of 15 lux (W3T2) gave the highest results with the highest egg production achievement reaching 22.40 ± 4.5 eggs.duck-1 with the total egg weight achievement of 1373.12 ± 16.5 g.duck-1, significant higher than other treatments with a production range of 13.06 - 20.53 eggs.ducks-1 and weight achievements ranging from 800.98 - 1258 g.duck-1 ($p < 0.05$). The lowest productivity is produced by the combination of yellow light with a light intensity of 10 lux (W1T1) and 15 lux (W1T2) with egg production of 13.06 ± 4.6 $eggs.duck^{-1}$, respectivelywith a total egg weight of 800, 98 ± 11.6 $g.duck^{-1}$.

Table 2. The average business income or Income over Feed Cost (IOFC) of Alabio Ducks for four weeks.

Treatment	Salling Value of Eggs (Rp.duck^{-1})	Cost of Feed Consumption (Rp.ekor^{-1})	(IOFC) (Rp.duck^{-1})
W1T1 (yellow color, 10 lux)	32039,20 ± 311,6^{a}	23.212,40 ± 250,6^{a}	8.826,81 ± 121,1^{a}
W1T2 (yellow color, 15 lux)	32039,20 ± 312,7^{a}	22.924,03 ± 259,7^{a}	9.115,17 ± 115,3^{a}
W1T3 (yellow color, 20 lux)	36616,40 ± 334,3^{b}	25.292,74 ± 224,3^{b}	11.323,66 ± 161,1^{b}
W2T1 (red color, 10 lux)	41193,60 ± 476,1^{b}	27.203,20 ± 202,1^{b}	13.990,38 ± 189,5^{b}
W2T2 (red color, 15 lux)	41193,60 ± 415,4^{b}	27.017,82 ± 212,4^{b}	14.175,78 ± 170,2^{b}
W2T3 (red color, 20 lux)	45770,40 ± 427,6^{c}	27.445,05 ± 205,6^{c}	18.325,35 ± 211,7^{c}
W3T1 (blue color, 10 lux)	45770,40 ± 435,2^{c}	27.548,10 ± 312,2^{c}	18.222,35 ± 191,6^{c}
W3T2 (blue color, 15 lux)	54924,80 ± 446,5^{e}	25.519,41± 289,5^{e}	29.405,39 ± 333,1^{e}
W3T3 (blue color, 20 lux)	50347,60 ± 452,9^{d}	26.168,13 ± 261,9^{d}	24.179,47 ± 211,2^{d}
W4T1 (green color, 10 lux)	45770,40 ± 313,9^{c}	27.908,50 ± 212,9^{c}	17.861,94 ± 221,6^{c}
W4T2 (green color, 15 lux)	50347,60 ± 454,5^{d}	25.828,29 ± 212,5^{d}	24.519,31 ± 211,9^{d}
W4T3 (green color, 20 lux)	50347,60 ± 434,1^{d}	26.054,87 ± 214,1^{d}	24.292,74 ± 231,9^{d}

Note: Figures followed by different superscripts in the same column show significantly different ($p < 0.05$), W: Light color; T: Light intensity; IOFC: Income Over Feed Cost; feed price of IDR 4500.kg^{-1}; the price of duck egg Rp. 2500.egg^{-1}; 1 kg of eggs is equivalent to 16 eggs of Alabio duck; one egg averaging 61,3 g.

This research shows that light that has short wavelengths such as blue light with wavelengths around 480 nm and green light with wavelengths of 520 nm are more effective at stimulating the retina of the eye to be able to stimulate the hypothalamus and pituitary gland in producing reproductive hormones namely the follicle stimulating hormone (FSH) and luteinizing hormone (LH) compared to the color of light with other long wavelengths such as yellow (580 nm) and red (700 nm) (Mohamed *et al.*, 2014), so that ovarian development and maturation is faster (Jin *et al.*, 2011; Hassan, *et al.*, 2013; Biyatmoko, 2014) While the best combination of light intensity of 15 lux achieved in producing egg production in this study is the recommended intensity range for laying poultry.Light at intensities of 10-20 lux is able to stimulate the process ovulation of ducks, while the color of light affects the wavelength it receives ik (Shabiha *et al.*, 2013). The difference in production levels due to the different colors and light intensities is in line with the results of research by Rozenboim *et al.* (2012) and Kim *et al.* (2012).

The color affects the behavior patterns of poultry, while sufficient light intensity will be able to bully the stimulation of the ovulation process of the egg that initiates egg production. The lack of intensity will inhibit the stimulation of ovulation that occurs due to inhibition of the secretion of the gonadotropin hormone in poultry. Irradiating blue and green colors make poultry quieter, food use efficiency (FCR) better and can be fully converted into eggs (Rozenboim, *et al.,* 2012; Hassan, *et al.,* 2013). On the other hand, the yellow and red light colors that cause ducks are more aggressive and active so that the consumption of feed is widely used to help energy in poultry locomotion so that egg production decreases. Energy and protein efficiency is fully manifested in producing egg production so that in addition to higher production, the weight of eggs produced is also greater and heavier for ducks that get blue and green LED monochromatic light colors (Freitas *et al.*, 2010).

This result corroborates the statement of Kasiyati *et al.,* (2010) which states that in white light blue laying eggs with an intensity of 15-25 lux will increase serum estradiol concentration, followed by an increase in ovarian weight and follicular diameter F1, where the greater the ovary and follicle diameter which is formed then causes the yolk (vittelin) to be bigger and the greater the weight of the egg.

Feed consumption and feed conversion ratio (FCR)

In Table 1, it can be seen that the highest consumption of duck ration was produced by the treatment of green light with a light intensity of 10 lux (W4T1) of 885.96 ± 12.9 g.duck^{-1} with an average consumption of 727.72 ± 9.7 g.duck^{-1} ($p < 0.05$). However, this consumption level indicator does not positively correlate with the level of duck egg production, because it is more determined by feed conversion (FCR) where the better the FCR (low FCR value), the higher and more efficient in egg production. Table 1 shows that the best FCR is produced by blue light treatment with a light intensity of 15 lux (W3T2) with an FCR value of 4.13 ± 1.3 linear with the highest level of production, while the worst FCR is produced by yellow light treatment with intensity 10 lux light (W1T1) with FCR reaching 6.44 ± 1.1 linear with the lowest egg production achievement of 13.06 ± 4.6 g.duck^{-1} is the same as W1T2 treatment egg production (yellow light color, intensity of 15 lux).

In general, the highest consumption of ration was produced by irradiation with red light (W2) with an average of 864.16 g.duck^{-1} is higher than other colors of light, followed by green light (W4) by 844.33 g. the blue color (W3) is 864.14 g.duck^{-1} and the last color is yellow light (W1) is 755.84 g.duck^{-1}.

The results of this study as stated by *Zhu et al.* (2019), where the use of red light can increase chicken locomotion which can trigger chicken aggressiveness so it is recommended to use it in the starter maintenance phase (brooding) because poultry is more active not in the egg production phase (Olanrewaju *et al.,* 2012). But if the intensity of light given is excessive can disrupt the daily rhythm (diurnal) egg production. Good irradiation in ducks other than the animal's preferred light color, blue and green, must also be balanced with adequate light intensity (number of lumens of light per watt) that ducks must receive, so that most of their feed consumption will be used fully for the egg production process (Li *et al.*, 2014). The vision of birds has a different sensitivity to the color of light where the color received by the retina of the eye will be able to distinguish colors with different levels of sensitivity according to differences in wavelength (Firouzi, *et al.,* 2014). Wavelength influences the behavior of poultry (Kim *et al.,* 2012). Feeding behavior of poultry, including ducks given irradiation in blue and green, will be calmer (Shabiha *et al.*, 2013).

Borille *et al.* (2013) stated that irradiating yellow light was not effectively given to laying poultry because it would show the lowest production yields and even reduce the level of egg production and efficient use of food (feed conversion ratio). Meanwhile, the illumination of blue light turns out to reduce locomotion (movement activity) and stand on ducks so that ducks become calmer (Huber *et al.,* 2013; Hassan *et al.,* 2014). Instead according to Firouzi *et al.* (2014), light functions to regulate daily rhythm and several important functions in the body such as body temperature and various metabolic stages associated with feeding and digestion. Feed consumption is more efficiently used to produce fully egg production because ducks do not waste a lot of energy for their locomotion in energy activities (Olanrewaju *et al.*, 2012). This makes improvements to the feed conversion as shown in Table 1 where the treatment of blue light with an intensity of 15 lux (W3T2) results in the best feed conversion (FCR) of 4.13 while the treatment of yellow light with an intensity of 10 lux (W1T1) produces the worst FCR is 6.44.

In Indonesia as a tropical country, the periodicity of solar lighting is only around 12 hours day^{-1} while the light requirement for poultry to be able to produce is 14-16 hours with sufficient intensity to stimulate the process of ovulation of eggs so the addition through artificial lighting (artificial light) at night is necessary (Biyatmoko, 2012). The addition of irradiation through the addition of six hours of light per day using ahemeral method to 18 hours of light and 10 hours of dark (one cycle of 28 hours.day^{-1}) is quite promising, because it is proven to be able to stimulate ovulation and increase the secretion of FSH hormone so that it bluffs activation. egg cells (ovaries) for oviposition or laying eggs (Hassan *et al.*, 2013) and significantly increase the yield of egg production and FCR of Alabio ducks in this study. These results reinforce the statement of Kasiyati (2018) that the use of longer bright light with a photoperiode of 16 bright hours: 8 hours dark (16L: 8D) increases the synthesis and secretion of estradiol in local poultry so that in the long run it can increase the number of functional ovarian follicles and guarantee sustainable egg production.

Income Over Feed Cost (IOFC)

Operating income or income over feed cost (IOFC) for four weeks of egg observation is presented in Table 2. Income over feed cost (IOFC) is income received from livestock businesses or in this case Alabio ducks are run, by looking at the margin of difference between the selling value of eggs produced with the cost of feed consumption (feed costs). The higher IOFC management, the higher the income generated and the more profitable. In Table 2, the highest income or IOFC is produced by the combination of blue light with a light intensity of 15 lux (W3T2) with an IOFC achievement of 29,405.39 ± 333.1 $Rp.duck^{-1}$ based on egg selling value of 54,924.80 ± 446, 5 $Rp.duck^{-1}$ and feed costs were 25,519.41 ± 289.5 $Rp.duck^{-1}$, while the lowest IOFC was produced by the combination of yellow light color with 10 lux light intensity of 8,826.81 ± 121.1 $Rp.duck^{-1}$ based on the sale value of eggs of 32,039.20 ± 311.6 $Rp.duck^{-1}$ and the feed costs of 23,212.40 ± 250.6 $Rp.duck^{-1}$.

Conclusion

The combination of blue light color with a light intensity of 15 lux (W3T2) can increase the ability of Alabio duck egg productivity with the highest egg production achievement of 22.40 ± 4.5 $eggs.duck^{-1}$, the total egg weight achievement of 1373.12 ± 16, 5 $g.duck^{-1}$, feed consumption of 810.12 ± 13.5 $g.duck^{-1}$, FCR value of 4.13 ± 1.3 and income over feed cost (IOFC) of 29,405.39 ± 333.1 $Rp.duck^{-1}$.

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