

Effect of Artificial Lighting Duration on Egg Production and Egg Quality of Local Chickens

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Abstract
Low egg production and long ovulation interval among chickens are the problems faced by farmers. Thus, an appropriate technology for increasing egg production is necessary. This study aims to analyze the effect of artificial light duration on egg production and egg quality of local chickens. This experiment, which has a completely randomized design, was conducted in the city of Palu, between December 2017 and September 2018. The hens were divided into G0 (control; 12 h lighting), G1 (13 h lighting), G2 (14 h lighting), and G3 (16 h lighting). Research variables were follicle-stimulating hormone (FSH) and luteinizing hormone (LH) concentration, egg production, clutch, and egg quality. Egg production was significantly influenced by the addition of light but not the quality of local-chicken eggs (egg weight, egg yolk index, egg white index, air sack diameter, yolk color, and shell thickness). Nonetheless, artificial light in G2 (12 h natural day light + 2 h artificial light) significantly influenced the increase of both FSH and LH concentrations at approximately 235.57 pg/ml (range, 162.15–397.72 pg/ml) and 1,021.98 pg/ml (range, 2,521.08–3,543.06 pg/ml), respectively. Chickens raised under a 14-hour artificial light achieved an increase in egg production without affecting egg quality.
Keywords: Artificial light, Egg Production, Quality of Egg, Local-chicken
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1. Introduction

Local chickens have been domesticated and raised traditionally by a community of poultry farmers (Haryono & Hidayat, 2012). Genetically derived from Patridge (Callus varis various L.), kampong chickens, which are now known as local chickens, are raised and used to meet life needs (Rahayu et al., 2011)(Rasyaf, 2011) (Arifin Zein & Sulandari, 2013). A laying hen that is raised well with maximum care can produce 250–300 eggs annually (reference needed). The main problem faced by chicken farmers, either traditionally or intensively for macro-, medium, or microbusiness scale, is the low egg production (Ramadoan, 2017) (Suryana, 2013). This deficiency is caused by some factors, such as relatively low growth compared with that in broiler, low and seasonal egg production, and the lack of management and high genetic variation of local chickens; as a result, many poultry farmers are still uninterested in raising this breed (Nurhapsa et al., 2017) (Suwandi et al., 2015). Maximum egg production can be achieved if factors such as day-old chicken, chicken food, and poultry management including environmental factors are being paid attention to. Environmental factors include climate, light or photoperiod temperature, humidity, air circulation, and nontechnical factors, such as noise and pollution (Riswantiyah & Zuprizal (Zuprizal), 1998). Thus, the implementation of science and appropriate technology in all aspects of poultry management to hasten the production needs is necessary.

Enhancing the egg production of local chickens is difficult to achieve if the egg production is limited; such shortcoming is in line with the increasing age. This decrement is due to the activity and physiological reproduction organ related to the level of blood calcium and hormonal function in stimulating the growth of preovulatory follicles, the reduction of egg-laying phase, and the increase of hens' age (Latifa, 2008). To overcome the decrease of chicken egg production, a previous researcher used the pituitary extract Pregnant Mare Serum Gonadotropin or PMSG hormone (Arum et al., 2013) (Moore & Ward, 1980) (Suriansyah et al., 2013). However, this hormone is seldom found in the local market and is relatively expensive (Siregar & Armansyah, 2009). Thus, a more comfortable, cheaper, and more applicative method for local-chicken farmers is the lighting method (Kasiyati, 2018).

The lighting effect in increasing chicken egg production has been extensively reported (Bédécarrats & Hanlon, 2017) (Shimmura et al., 2006). However, the time and duration for lighting have not obtained a gold standard yet. Artificial lighting (AL) can be utilized to trigger the release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the pituitary to produce more eggs and to support egg embryo growth (Liu et al., 2010) (Raju et al., 2013).

Local-chicken egg production is limited, and local-chicken egg needs are increasing; thus, an easy and inexpensive method should be employed by local-chicken farmers. The method of injecting FSH and LH into local chickens is expensive for these farmers; hence, the lighting method had been analyzed in this study. This study aimed to examine the effect of AL duration on the egg production and egg quality of local chickens.

2. Methods

The present experiment was conducted in the city of Palu, from December 2017 to September 2018, by using a completely randomized design. Adding an AL was the intervention applied for the FSH and LH concentrations, production, phase, and egg quality of local chickens. This research consisted of four experimental groups with three repetitions. Each repetition consisted of three local chickens; hence, the total number of chickens used was 36.

2.1 Chicken Groups.

Table 1. Chicken Groups

Experimental group	Information
G0	Natural day light (sunlight) for 12 h at 6:00 AM–6:00 PM daily
G1	AL for 1 h at 6:00 PM–7:00 PM and sunlight for 12 h daily (13 h of lighting).
G2	AL for 2 h at 6:00 PM–8:00 PM and sunlight for 12 h daily (14 h of lighting)
G3	AL for 4 h at 6:00 PM–8:00 PM and 4:00 AM–6:00 AM, and sunlight for 12 h daily (16 h of lighting).

2.2 Method of Data Collection

Egg Production. Egg production is the number of eggs produced by local chickens in each treatment group. We checked and calculated the number of eggs generated by each local-chicken every day. **Egg Quality**. The data on the exterior and interior quality of local-chicken eggs were collected as follows: (Wesley & Stadelman, 1959) (Rath et al., 2015). 1) In obtaining the egg weight data, each egg was weighed using the scales with 0.1 scale; 2) The data on the shape of the eggs were evaluated as either round, oval, or elliptical. If the width and length were equal, then it was round; if the width was smaller than the length, then it was elliptical; if the width and the height were 2/3, then it was an oval; 3) The cleanliness of the egg yolks (eggshells) was evaluated according to the presence or absence of stains or dirt on the eggshells; 4) The thickness of the eggshells was determined by taking one part of the eggshells and measuring the thickness using digital calipers; 5) The egg yolk index was determined on the basis of the measurement of the height and diameter of the egg yolks using digital calipers. The height measurement started from the base of the yolks in the container until the highest peak of the egg yolks, whereas the diameter was measured from the distance of the edges of the egg yolks to the midpoints. The egg yolk index was identified using the following formula: egg yolk index = the height of egg yolk ÷ the diameter of egg yolk. To determine the index of the egg whites, we used the following formula: egg white index = the height of the egg white ÷ the diameter of the egg white. 6) The measurement of the air sacks was determined by taking the blunt parts where the air sacks can be found. The air sacks were measured from the bottom of the air sacks to the highest peaks, and the diameters were measured from the edges of the air sacks to the midpoints.

2.3 Materials Used

This research used 36 productive hens; FSH (Chicken: Fine Test, China) and LH (Chicken: Fine Test, China); poultry food for starter, grower, and layer periods with corn composition (150 kg); concentrate (100 kg); dedak (50 kg); vitamins and minerals; water; ND-IB live vaccine; ND-AI kill vaccine; anthelmintic (Nemasol); sands; and fine chalk. The equipment used were 3 ml disposable syringe, container for food and water, caliper, 0.1 g scale, lamp with a power of 190–204 lx, food candle, yolk color fan, camera, stationery, watch, label paper, ruler, broomsticks, shovels, plates, tube racks, and black tarps.

2.4 Statistical Analysis

The one-way ANOVA was conducted using the SPSS program version 16 with a significance level of $P < .05$. If the F count results showed a significant result, then we proceeded with the honestly significant difference test to determine whether the average between more than two different groups have any differences.

3. Results and Discussion

3.1 Egg Production

The number of eggs produced by the local chickens among the four experimental groups had significant differences (G0–G3). The G2 group with 23.11 ± 1.53 eggs/chicken had the highest number of eggs. Meanwhile, the G3 group had the heaviest egg weight, which was 47.13 ± 5.29 g/egg, whereas the G0 group had the lightest egg weight, which was 43.63 ± 4.08 g/egg (Table 2).

The distance of the eggs (days) showed that significant differences existed among the four experimental groups. The G2 group had the smallest clutch of 1.32 ± 0.02 days, indicating that chickens in this experimental group needed 1.32 days to lay eggs again, whereas the other experimental groups needed approximately 2 days (Table 2).

3.2 Egg Quality

The egg quality, which refers to the egg white index (albumen), egg yolk index, air sack diameter, egg yolk color, and eggshell thickness, showed that no significant differences were found between the experimental groups. Thus, either providing additional light or not (regular) did not have a significant influence on the egg quality of the local chickens (Table 2).

The statistical analysis Average egg production value, clutch size, and egg quality of local chickens among the four experiment groups show table 2.

Table 2: Average egg production value, clutch size, and egg quality of local chickens among the four experiment groups.

Research Variable	Experiment			
	G0 (12 h)	G1 (13 h)	G2 (14 h)	G3 (16 h)
Egg Production				
Egg total (eggs/chicken)	15.11 ± 2.89	17.33 ± 1.30	23.11 ± 1.53*	18.66 ± 4.62
Egg weight (g/egg)	43.63 ± 4.08	44.14 ± 4.60	44.75 ± 7.66	47.13 ± 5.29
Clutch				
Distance among eggs (day)	2.15 ± 0.25	2.03 ± 0.09	1.32 ± 0.02	1.72 ± 0.13
Egg total per egg-laying phase (eggs/day)	15–18 eggs/ 43.20 days	17–19 eggs/ 39.50 days	23–25 eggs/ 33.02 days	19–23 eggs/ 43.07 days
Egg Quality				
Egg white index (albumen) (cm)	0.13 ± 0.01	0.16 ± 0.08	0.14 ± 0.03	0.15 ± 0.04
Egg yolk index (cm)	0.46 ± 0.02	0.45 ± 0.08	0.46 ± 0.01	0.47 ± 0.08
Air sack diameter (mm)	7.93 ± 5.07	6.19 ± 7.08	8.55 ± 2.12	7.31 ± 6.11
Egg yolk color	7.04 ± 0.06	7.06 ± 0.1	6.99 ± 0.32	7.03 ± 0.1
Eggshell thickness (cm)	0.33 ± 0.01	0.32 ± 0.02	0.33 ± 0.03	0.35 ± 0.05

* P < .05

Results show that AL has a significant influence on egg productivity. Based on the four experiments, the treatment of 2 h AL, that is, G2, had a significant effect, considering that this group had the highest number of eggs produced (23.11 grains/chicken). Conversely, G0 had the least number of eggs produced (15.11 grains/chicken).

Chickens need light to be able to produce optimally. The existence of lighting both derived from natural light (sunlight) and AL stimulates the hypothalamus, then passed on to the body's glands, such as the pituitary, thyroid, and parathyroid, to secrete hormones. Particularly, the pituitary gland secretes FSH and LH. Both of these hormones are extremely important for egg growth (Lewis et al., 2005).

The G2 group, which received the 2 h AL experiment, had the highest FSH and LH concentrations among all the experimental groups. The lighting period (photoperiod) setting influences the reproductive hormone system of the poultry (Yang et al., 2017). The light has two functions in the setting of the reproductive season, namely, as a condition that influences the endogenous rhythms of biology and as a stimulus for various neuroendocrine system processes, such as gametogenesis, ovulation, secondary genital organ function, and reproduction (Van Tienhoven, 1983).

Moreover, G2 had the highest FSH and LH concentrations, which were 397.72 and 3,543.06 pg/ml, respectively. Thus, the lighting of more than 12 h per day can increase the concentration of these hormones. Various research findings on lighting aspects affect the reproductive traits of poultry. For instance, replacing red light for 14 h with green light for 2 h increases the production of FSH and estradiol, ovarian weight, and the number of follicles, thereby considerably influencing the egg production; (Hassan et al., 2013) the red light and the light used with 16 h bright photoperiod for 8 dark hours (16 L: 8D) increase the synthesis and secretion of estradiol in local poultry; thus, in a long term, it can increase the number of functional ovarian follicles and ensure sustainable egg production (Kasiyati, 2018). Furthermore, the light experiment in the form of red, green, or blue monochromatic light can be potentially used to optimize the productivity of chickens (Desly et al., 2016).

The long duration of natural lighting from the sunlight generally lasts for only 12 h. If the lighting time is less, the egg production will drop and can even stop. Without lighting, chickens experience feather loss, and to a great extent, they stop laying eggs for approximately 2 months (Susanti et al., 2012). The lighting time for poultry continues to expand until the production phase (layer). Provision of solar lighting and additional lights, or lights for more than 12 h, is proven to increase the egg production of chickens to 20%–35% (Pertiwi, 2016).

Other research results show that AL programs influence egg production (Jácome et al., 2014). Light can influence behavior, metabolic speed, physical activity, and physiological factors, such as those involved in the reproductive system (Mulyantini, 2014). Chickens with different age levels require different lighting, duration, light intensity, and lamp voltage (Mendes et al., 2013). The lighting addition is adjusted on the basis of the age of the chicken, aiming to maximize the growth and production of chickens according to their needs.

The proper lighting settings for the laying hens can produce high amounts of egg production and a high percentage of hatching egg (Dewi et al., 2018). Chickens that are lighted for 8 h during the growth period and 14 h during the layer can produce more eggs (significantly different) even though the weight of the eggs is slightly lighter (Amrullah, 2003). The night lighting can increase feed consumption, causing an impact on the weight of the poultry bodies (Abidin, 2003). Hence, light plays a role in feed consumption and body weight. The role of light is also considerably closely related to the egg production and size because it stimulates the work of hormones for the growth and the cooking of the prospective eggs (Johari, 2005). This study recommends the addition of light for 2 h from natural light (sunlight), so that the chicken will be exposed to light for a total of 14 h a day to increase the amount of local-chicken egg production.

4. Conclusions

In conclusion, the G2 group, which was exposed to 2 h AL, had a significant influence on the total number of produced eggs compared with the other experimental groups. The quality of local-chicken eggs produced from the four treatment groups remained the same. Thus, local-chicken farmers could use lighting methods to increase egg production. Therefore, 2 h lighting can be applied by poultry farmers to obtain more local-chicken eggs than the other methods. This method is also tremendously easy, efficient, and inexpensive.

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