Australian Journal of Science and Technology

ISSN Number (2208-6404)
Volume 8; Issue 3; September 2024

Original Article

# The effect of retinal and extra retinal photo stimulation by light emitting diode light on the performance, blood properties, and meat qualities of broiler chicks

**Md. Rakibul Hassan[1]*, Md. Ataul Goni Rabbani[2], Shabiha Sultana[2], Nathu Ram Sarker[3], Eshtiak Ahamed Pehan[4], Nasrin Sultana[5]**

[1]Dairy Research and Training Center, Poultry Production Research Division, Bangladesh Livestock Research Institute, Savar, Dhaka, Bangladesh, [2]Poultry Production Research Division, Bangladesh Livestock Research Institute, Savar, Dhaka, Bangladesh, [3]Krishi Gobeshona Foundation, BARC Campus, Farmgate, Dhaka, Bangladesh, [4]Dairy Research and Training Center, Bangladesh Livestock Research Institute, Savar, Dhaka, Bangladesh, [5]Office of the Director Research, Bangladesh Livestock Research Institute, Savar, Dhaka, Bangladesh

## ABSTRACT

The experiment was undertaken to know the effect of different light wavelength on the performance, meat qualities, and blood properties of broiler chicken. A total of 600-day old broiler chicks were weighted and equally allotted to the following five light treatments with six replications: red (R 660–670 nm), yellow (Y 590–610 nm), green (G 540–560 nm), and blue (B 460–470 nm) light colors. Fluorescent white light was the control. Body weight (BW), weight gain (WG), feed intakes (FIs), and feed conversion ratio were measured weekly. During the pre-starter period (0–7 days), G light treatment showed increased BW compared to that in the other groups. A significant ($P < 0.05$) increase in WG was found in the G treatment compared to that in the R and W treatments during the starter period (2–3 weeks). Therefore, WG was significantly higher ($P < 0.05$) in the B treatment during the growing period (4–5 weeks) than that R and W treatments. Both FI and feed conversion ratio were not affected by the light treatments. Serum erythrocyte sedimentation rate was significantly decreased with light wavelengths. Serum lipid parameter (glucose, total protein, cholesterol, and low-density lipoprotein) was not influenced by the light color, but high-density lipoprotein level was significantly increased by the B light treatment. Dressing % of meat, muscular pH and redness (a*) of meat were significantly increased with decreasing light wavelengths. In conclusion, the G lighting treatment enhanced growth performance and improved meat quality of broiler chicks compared to those of monochromatic R and W light.

**Keywords:** Broiler chicks, light emitting diode light color, meat and blood properties, performance

**Submitted:** 03-08-2024, **Accepted:** 11-09-2024, **Published:** 30-09-2024

## INTRODUCTION

Artificial light in poultry houses can different from that of natural light.[1] In modern poultry industry, it is pointed out that long wavelength stimulates reproduction and short wavelength enhances growth and immunity through sympathetic and parasympathetic nerve stimulation.[2,3] This nerve stimulation regulates many physiological functions to enhance poultry production. Avian species are wavelength sensitive and respond differently to various light colors than human.[4,5] The eye (retina), the penial gland, and the deep brain tissue are the three major sites have been shown to contain photoreceptors[6] and respond maximally to violet, blue, green, and yellow[7] which are important for endocrine glands that secret hormones directly into the blood.[5] Therefore, poultry producers are searching for better, energy saving solutions over incandescent and fluorescent lamps. Light emitting diode (LED) light saves energy by up to 83% and thus, impacting flock performance and poultry producer's income.[8] Therefore, use of LED is gaining popularity in different fields such as plant growth and eradication of mosquitoes.[9] In human studies, LEDs are used to treat

**Address for correspondence:** Md. Rakibul Hassan, Bangladesh Livestock Research Institute, Savar, Dhaka, Bangladesh.
E-mail: mdrakibulhassan@gmail.com

problems such as sleep disorders, seasonal affective disorder, neonatal jaundice, and repair bone defects.[10,11]

In broiler performance trials, several authors have mentioned that monochromatic green light enhances growth performance in the early stage and blue in the later stage.[2,12-14] Therefore, South Korea, Denmark, USA, Canada, China, Brazil, Israel, Turkey are using LED lighting system. In Bangladesh, there is little information on whether monochromatic light stimuli that show growth-promoting effects of broiler chicks. Hence, the present experiment was designed to know the effect of monochromatic LED light color on performance, meat qualities, and blood properties of broiler chicken.

## MATERIALS AND METHODS

### Birds and Housing Management

A total of 600-day old broiler chicks were weighed without sexing and placed in 30 pens (5 light conditions × 6 replicates) and each room contained 20 birds. The light treatments were (1) red LED light (R), at a peak wavelength of 660 nm, half band width between 650 and 670 nm, (2) yellow (Y 590–620 nm) at a peak wavelength of 620 nm, half band width between 595 and 620 nm, (3) green light (G) at a peak wavelength of 560 nm, half band width between 540 and 560 nm, (4) blue light (B) at a peak wavelength of 460 nm, half band width between 455 and 470 nm (5) control (compact fluorescent white, 400–770 nm). The room temperature was maintained at 33°C for the 1st week, and then reduced by 2–3°C per week until it reached 22°C, which was maintained until the end of the experiment. The birds were reared for three growing phases, i.e., 0–7 days, 8–21 days and 22–35 days of age, and three diets with prestarter, starter, and grower feed respectively. The broilers had free access to feed and water throughout the experimental periods. Body weights (BWs) of broilers were determined at 7, 14, 21, 28, and 35 days of age. Feed consumption and weight gain (WG) were recorded during the different periods and the feed conversion ratio (FCR; food intake/WG) was calculated.

### Meat Quality Determination

At the end of the experiment, eight broiler chicks per treatment were randomly selected and euthanized by cervical dislocation, and the pectoral muscle was collected. Meat color (CIE) L* (lightness), a* (redness), and b* (yellowness) color space values were obtained for pectoral muscle samples using a Minolta colorimeter. The pH of each pectoral muscle sample was determined using a digital pH meter. To determine the cooking loss, pectoral muscle samples were heated and removed when internal temperature reached 74°C. Cooking loss was determined based on the formula: Cooking loss = (initial weight-cooked weight/initial weight) × 100.

### Blood Properties

At the end of the experiment, eight blood samples per treatment were taken by puncturing the wing vein and serum was collected and stored at −20°C until analysis. Biochemical blood parameters, including glucose (GLU, mg/dL), total cholesterol (mg/dL), triglycerides (mg/dL), and high-density lipoprotein (HDL) (mg/dL) were measured by using a Humalyzer 2000 Chemistry (2000) using turbidimetric method as described by the manufacturer.

### Statistical Analysis

All data were analyzed by one-way analysis of variance using the PROC GLM procedure in SAS (9.1 SAS Institute, Cary, NC, USA, 2002). The treatment arrangement consisted of different light color. Light color was a fixed effect; whereas pens were random. For BW, WG, feed intake (FI) and FCR the pens ($n$ = 6) were the experimental units. For other parameters ($n$ = 8), birds were considered as the experimental unit. Whenever significant differences were found between treatments ($P \leq 0.05$), values were compared by Duncan's new multiple-range (Steel and Torrie, 1980). A $P < 0.05$ was considered significant.

## RESULTS AND DISCUSSION

In the present experiment, growth performances from 1 to 35 days are presented in Table 1. During the overall study period, the BW and WG of chickens were affected by light color ($P < 0.05$). During the 0–7 days, BW and WG were not influenced by light color. The WG of birds differed ($P < 0.05$) during 2–3 weeks of age, when the significantly highest WG was obtained in the birds reared under the G light treatment. During 4–5 weeks of age, the birds were heavier under the G light treatments. However, no significant difference was observed in WG among the G, B, and Y treatments. This result may have been due to B lighting stimulating the anterior hypothalamus which is the main regulatory part of the parasympathetic nervous system, thereby decreasing blood pressure and increasing blood flow and enhancing the supply of oxygen and nutrients to meat, which lead to increased growth performance.[15] Our previous results also correspond with the present findings.[2] In another experiment, it was reported that B and G light enhances proliferation of skeletal muscle satellite cells and thus increases protein synthesis and growth performance.[12,16,17]

Light color did not affect FI at 0–7 days, 8–21 days, and 22–42 days of age, whereas it numerically increased under the G treatment. During 8–21 days and 22–42 days, G light birds tended to consume more feed. During the overall experimental period, numerically higher FI was recorded under the G treatment. During 1–35 days of age, FCR values were not significantly influenced by light treatment but tended to increase under the G and B treatments.

At 35 days of age, blood properties were not significantly influenced by light color, but HDL level was significantly

**Table 1: Effect of LED light color on the performance of broiler chicks**

| Parameter | Treatments | | | | | SEM | *P*-value |
|---|---|---|---|---|---|---|---|
| | Red | White | Yellow | Green | Blue | | |
| Body weight (g) | | | | | | | |
| At 7 day | 184.25 | 179.44 | 181.25 | 186.50 | 183.04 | 1.656 | 0.736 |
| At 21 day | 931.81$^{b}$ | 926.33$^{b}$ | 948.33$^{ab}$ | 1002.8$^{a}$ | 946.57$^{ab}$ | 5.36 | 0.025 |
| At 35 day | 2025.47$^{b}$ | 2040.5$^{b}$ | 2079.5$^{ab}$ | 2126.3$^{a}$ | 2063.3$^{ab}$ | 10.28 | 0.029 |
| Weight gain (g) | | | | | | | |
| 0–7 day | 135.25 | 130.44 | 132.25 | 137.50 | 134.04 | 1.656 | 0.736 |
| 8–21 day | 747.56$^{b}$ | 747.09$^{b}$ | 767.07$^{ab}$ | 816.38$^{a}$ | 763.6$^{ab}$ | 5.051 | 0.041 |
| 0–21 day | 880.94$^{b}$ | 876.85$^{b}$ | 898.02$^{ab}$ | 953.14$^{a}$ | 897.1$^{ab}$ | 5.31 | 0.045 |
| 22–35 day | 1094.88$^{b}$ | 1113.9$^{b}$ | 1131.8$^{ab}$ | 1174.0$^{a}$ | 1116.6$^{ab}$ | 10.27 | 0.012 |
| 0–35 day | 1975.82$^{b}$ | 1990.8$^{b}$ | 2029.8$^{ab}$ | 2077.2$^{a}$ | 2013.7$^{ab}$ | 7.59 | 0.041 |
| Feed intake (g) | | | | | | | |
| 0–7 day | 152.22 | 151.46 | 157.04 | 154.03 | 154.82 | 1.039 | 0.594 |
| 8–21 day | 1189.18 | 1199.17 | 1226.61 | 1230.27 | 1162.40 | 9.949 | 0.134 |
| 0–21 day | 1355.93 | 1361.10 | 1394.22 | 1395.03 | 1323.80 | 10.23 | 0.141 |
| 22–35 day | 2025.49 | 2040.08 | 2021.43 | 2081.10 | 2044.10 | 13.98 | 0.392 |
| 0–35 day | 3381.40 | 3401.18 | 3415.65 | 3476.13 | 3367.90 | 21.36 | 0.359 |
| Feed conversion ratio | | | | | | | |
| 0–7 day | 1.146 | 1.170 | 1.190 | 1.128 | 1.156 | 0.014 | 0.764 |
| 8–21 day | 1.591 | 1.606 | 1.602 | 1.507 | 1.522 | 0.014 | 0.462 |
| 0–21 day | 1.539 | 1.556 | 1.554 | 1.463 | 1.475 | 0.013 | 0.308 |
| 22–35 day | 1.849 | 1.831 | 1.786 | 1.772 | 1.830 | 0.031 | 0.819 |
| 0–35 day | 1.711 | 1.708 | 1.682 | 1.673 | 1.672 | 0.039 | 0.138 |

LED: Light emitting diode, $^{a,b}$Mean values within a column followed by the same letter are not significantly different (p≥0.05)

**Table 2: Effect of LED light color on blood properties of broiler chicks**

| Parameters | Treatments | | | | | SEM | *P*-value |
|---|---|---|---|---|---|---|---|
| | Red | White | Yellow | Green | Blue | | |
| Red blood cells | | | | | | | |
| Hemoglobin % | 9.35 | 10.18 | 10.26 | 9.56 | 9.44 | 0.196 | 0.184 |
| ESR (mm in 1$^{st}$ h) | 9.60$^{ab}$ | 11.20$^{a}$ | 8.80$^{b}$ | 7.00$^{ab}$ | 7.00$^{b}$ | 0.597 | 0.047 |
| Lipid properties | | | | | | | |
| Glucose (mg/dL) | 228.72 | 217.68 | 218.30 | 209.9 | 207.6 | 5.78 | 0.314 |
| Cholesterol (mg/dL) | 182.58 | 184.54 | 194.76 | 179.6 | 168.8 | 2.73 | 0.178 |
| HDL (mg/dL) | 118.1$^{ab}$ | 97.7$^{b}$ | 118.8$^{ab}$ | 117.8$^{ab}$ | 128.1$^{a}$ | 4.19 | 0.031 |
| LDL (mg/dL) | 33.16 | 37.14 | 35.36 | 33.16 | 29.30 | 1.93 | 0.172 |
| Total protein (g/dL) | 7.14 | 7.52 | 7.78 | 7.08 | 6.74 | 0.914 | 0.240 |

LDL: Low-density lipoprotein, LED: Light emitting diode, HDL: High-density lipoprotein, ESR: Erythrocyte sedimentation rate, $^{a,b}$Mean values within a column followed by the same letter are not significantly different (p≥0.05)

increased by the B light treatment [Table 2]. The variation in light color did not affect hemoglobin percentage in blood, but serum erythrocyte sedimentation rate (ESR) was significantly decreased with light wavelengths. On the other hand, serum lipid parameter (GLU, total protein, cholesterol, and low-density lipoprotein) was not influenced by the light color. However, no significant differences of ESR were observed in R and G light treatments. This result may have been due to the finding that B lighting stimulates the anterior hypothalamus which is the main regulatory part of parasympathetic nervous system and it can be stimulated by bile secretion, which accounts for the majority of cholesterol breakdown in the

body.[18] The present result corresponds with our previous finding.[19]

In the present results, no significant light color effects were observed in cooking loss, but the G light color treatment significantly increased dressing % that of the other treatments. The results also showed that CIE (L*, a*, b*) values were not influenced by light color, but B light resulted in a higher redness (a*) value. Similarly, B lighting increased meat pH indicating better meat quality that was characterized by lower protein damage and increased meat color (a*) which confirms our previous results.[20,21]

## CONCLUSION

The application of the green and blue LED light can be used to improve growth performance, blood and meat quality in broiler chicks. Further follow up experiment is needed to know the performance under 12 h natural light and 12 h artificial light condition in Bangladesh.

## REFERENCES


1. Lewis PD, Morris TR. Poultry and coloured light. Poult Sci 2000;56:189-207.
2. Hassan MR, Sultana S, Kim SH, Ryu KS. Effect of various monochromatic LED light colours on performance, blood properties, bone mineral density, and meat fatty acid composition of ducks. J Poult Sci 2017;54:66-72.
3. Hassan MR, Sultana S, Kim SH, Ryu KS. Effect of monochromatic and combined LED light colours on the performance, blood properties, meat fatty acid composition and immunity of broiler chicks. Eur Poult Sci J 2016;80:136.
4. Karakaya M, Parlat SS, Yilmaz MT, Yildirim I, Ozalp B. Growth performance and quality properties of meat from broiler chickens reared under different monochromatic light sources. Br Poult Sci 2009;50:76-82.
5. Olanrewaju HA, Purswell JL, Collier SD, Branton SL. Effects of colour temperatures (Kelvin) of LED bulbs on blood physiological variables of broilers grown to heavy weights. Poult Sci 2015;94:1721-8.
6. Prescott NB, Wathes CM. Spectral sensitivity of the domestic fowl (*Gallus* g. *domesticus*). Br Poult Sci 1999;40:332-9.
7. Dartnall HJ, Bowmaker JK, Mollon JD. Human visual pigments: Microspectrophotometric results from the eyes of seven persons. Proc R Soc Lond B Biol Sci 1983;220:115-30.
8. Kim MJ, Parvin R, Mustaq MM, Hwangbo J, Kim JH, Na JC, *et al*. Growth performance and hematological traits of broiler chickens reared under assorted monochromatic light sources. Poult Sci 2013;92:1461-6.
9. Han IS, Cho HY, Moni A, Lee AY, Briggs WR. Investigations on the Photoregulation of Chloroplast movement and leaf positioning in *Arabidopsis*. Plant Cell Physiol 2013;54:48-56.
10. Holzman DC. What's in a color? The unique human health effects of blue light. Environ Health Perspect 2010;118:A22-7.
11. Pinheiro AL, Soares LG, Barbosa AF, Ramalho LM, Dos Santos JN. Does LED phototherapy influence the repair of bone defects grafted with MTA, bone morphogenetic proteins, and guided bone regeneration? A description of the repair process on rodents. Lasers Med Sci 2021;27:1013-24.
12. Rozenboim I, Biran I, Chaiseha Y, Yahav S, Rosenstrauch A, Sklan D, *et al*. The effect of a green and blue monochromatic light combination on broiler growth and development. Poult Sci 2004;83:842-5.
13. Ke YY, Liu WJ, Wang ZX, Chen YX. Effects of monochromatic light on quality properties and antioxidation of meat in broilers. Poult Sci 2011;90:2632-7.
14. Baxter M, Joseph N, Osborne VR, Bedecarrats GY. Red light is necessary to activate the reproductive axis in chickens independently of the retina of the eye. Poult Sci 2014;93:1289-97.
15. Dauchy RT, Dauchy EM, Hanifin JP, Gauthreaux SL, Mao L, Belancio V, *et al*. Effects of spectral transmittance through standard laboratory cages on circadian metabolism and physiology in nude rats. J Am Assoc Lab Anim Sci 2013;52:146-56.
16. Halevy O, Piestun Y, Rozenboim I, Reuveni ZY. *In ovo* exposure to monochromatic green light promotes skeletal muscle cell proliferation and affects myofiber growth in posthatch chicks. Am J Physiol Regul Integr Comp Physiol 2006;290:1062-70.
17. Cao J, Wang Z, Dong Y, Zhang Z, Li J, Li F, *et al*. Effect of combinations of monochromatic lights on growth and productive performance of broilers. Poult Sci 2012;91:3013-8.
18. Klinghardt D. The neurophysiology of light, the five pathways. J Optom Photother 2003;35-40.
19. Jung JM, Hassan MR, Lee DH. Alterations in Whole Blood Viscosity and Blood Properties in Duck Rearing under Different Monochromatic LED Light Sources. Grorgia, USA: International Poultry Science Forum; 2014. p. 27-8.
20. Rathinam T, Kuenzel WJ. Attenuation of gonadal response to photostimulation following ablation of neurons in the lateral septal organ of chicks. Brain Res Bull 2005;64:455-61.
21. Sultana S, Hassan MR, Choe HS, Ryu KS. Effect of monochromatic and mix LED light colour and age on the behaviour and fear responses of broiler chicken. Avian Biol Res 2013;6:207-14.