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*Research Article*

# Evaluation of broiler performance reared under monochromatic light emitting diode (LED) tubes vis-a-vis incandescent light supplemental lighting

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**ABSTRACT**

This study was conducted to evaluate the effect of different monochromatic LED lights on the performance of broiler chickens. A total of 120 day-old Lohmann Meat (Indian River) broiler chicks were randomly assigned to three treatment groups: incandescent light (control), red LED light and white LED light, with each group consisting of four replicates of 10 chicks. The chicks exposed to LED lighting showed higher average live weight and live weight gain compared to the control group, while no significant differences (P>0.05) were observed in feed intake, feed conversion ratio and survivability. Carcass yields, including breast, thigh, drumstick, wing, neck, liver, heart, and spleen, were not significantly affected by the different monochromatic lighting sources (P>0.05). However, significant differences (P<0.05) in the weights of the back and proventriculus were observed between the white LED group and the other treatment groups. These results suggest that LED lighting could serve as a better alternative to incandescent bulbs in broiler houses, with the potential to enhance broiler performance and carcass yield.



## INTRODUCTION

The broiler industry has become one of the most rapidly expanding sectors in poultry production. However, one of the primary challenges facing this industry during broiler rearing is the high power consumption, which significantly raises production costs (Yanagi Junior *et al*., 2011; Pereira *et al*., 2012). With the quick expansion of the global population, the demand for animal protein, such as chicken meat, has surged, contributing not only to increased employment opportunities but also to the improvement of public health. Over the past few decades, genetic selection in broiler production has predominantly focused on traits like rapid growth, resulting in increased live weight gain and more efficient feed conversion. However, this targeted selection has inadvertently led to the development of several undesirable traits in broilers including skeletal disorders, ascites (fluid accumulation), sudden death syndrome, reduced immune function, poor reproductive performance and decreased meat quality. Consequently, producers have been compelled to adopt better management practices to mitigate these issues without compromising production efficiency. One key practice that has become essential in optimizing broiler production is light management, which helps to mitigate the challenges of rapid growth while improving both bird welfare and overall productivity. Light plays an important role not only in visual acuity and color perception (Calvet *et al*., 2009) but also significantly influences the behavior, physiology, and production performance of birds (Pravin *et al*., 2014; Kristensen *et al*., 2007). Additionally, studies have indicated that manipulating light in poultry shed can serve as an effective strategy to enhance poultry production (Hassan *et al*., 2014; Yang *et al*., 2016). Traditional lighting systems, predominantly based on incandescent or fluorescent bulbs, have been widely utilized in broiler houses. However, traditional lighting systems frequently exhibit challenges related to energy efficiency, light quality, and durability, which can hinder optimal performance in poultry production systems. Light Emitting Diode (LED) technology has emerged as a promising alternative, offering numerous advantages that could potentially enhance broiler production (Santana *et al*., 2014). The broiler is a photosensitive bird and their behavior, as well as overall welfare, can be significantly influenced by the lighting conditions within their environment (Mendes *et al*., 2013). The wavelength, photoperiod, light intensity, type and placement of lighting are all critical factors that influence the development and performance of birds (Olanrewaju *et al*., 2006; Capar Akyuz and Onbasilar, 2018; Soliman and EL-Sabrout, 2020). Over the past fifty years, extensive research has focused on enhancing broiler chicken performance through artificial lighting, as producers aim to boost live weight gain while ensuring efficient feed conversion and maintaining bird health (Rogers *et al*., 2015). In recent times, LED lamp has drawn more attention in poultry production due to its high energy efficiency (Huber-Eicher *et al*., 2013), durability, availability in various wavelengths, low power consumption, and reduced rearing costs (Rogers *et al*., 2015). Cao *et al.* (2008) investigated four colors of LED lighting (white, red, blue and green) in poultry production and reported varying outcomes. Conversely, Paixao *et al.* (2011) examined two types of light sources (fluorescent and white LED) and found no significant differences in broiler performance. The artificial lighting used in poultry farming largely reflects technologies designed for human use, and there is limited research on the effects of poultry-specific lamps on broiler productivity. Consequently, this study aims to investigate the effects of an LED tube artificial lighting system on the performance and carcass characteristics of broiler chickens, comparing various LED colors with incandescent bulbs.

## MATERIALS AND METHODS

### Place of work

The current study was carried out at the open-sided poultry research farm under the Department of Animal Nutrition, Genetics, and Breeding at Sher-e-Bangla Agricultural University, located in Sher-e-Bangla Nagar, Dhaka-1207.

### Experimental design and birds

A completely randomized design was applied in this experimental research, using artificial red and white LED lighting systems to evaluate the effects of LED tubes on the production performance and carcass characteristics of broiler chickens over a period of 28 days. A total of 120 day-old broiler chicks were randomly allocated to three experimental groups, with each group having four replicates of 10 birds. The experiment involved three treatments: two different colored LED bulb (3 Watts each), including one white ($T_w$) and one red ($T_r$), as well as incandescent bulbs (60 Watts each) serving as the control ($T_c$). The allocation of birds in each experimental group was performed using a random number generator, ensuring that each bird had an equal chance of being assigned to any treatment group.

### Housing and management of birds

Before arrival of day old chicks at the farm, the experimental shed was thoroughly cleaned, treated with bleaching powder, and the floor was washed using clean water. Before placing the chicks, the shed was fumigated with formalin and potassium permanganate at a ratio of 500 ml formalin to 250 g potassium permanganate (2:1) for a 35 m³ experimental area. After the chicks arrived at the farm, their initial weights were measured using a digital balance. Each experimental pen was equipped with a plastic feeder and drinker, both of which were adjusted in size according to the age of birds. The feeders and drinkers of the experimental pen were cleaned weekly. The stocking density was maintained at 1 m² per 10 birds. Only clean, sun-dried rice husk, placed 6 cm deep, was used as a shallow litter to absorb moisture from the droppings of broiler chicks. Around 200 g of calcium powder was mixed thoroughly with the rice husk in each pen to use as a disinfectant. The litter was turned weekly to prevent the accumulation of toxic gases, reduce moisture, and minimize parasitic infestations. Crumble feed was provided as the starter diet (0-2 weeks), followed by pellet feed for the grower phase (3-4 weeks). *Ad libitum* feeding, along with access to fresh and clean drinking water, supported the rapid growth of broilers throughout the four-week period. Leftover feed and water were recorded to determine the actual intake. The starter and grower rations were formulated to contain 22% and 20% crude protein, with metabolizable energy of 3000 and 3100 Kcal ME/Kg of feed, respectively (Table 1).

**Table 1.** Ingredients and nutritional composition of the diet provided to broiler chicks

| **Ingredients%** | **Starter** | **Grower** |
|---|---|---|
| Corn | 51.3 | 58.5 |
| Soybean meal 44% | 22.6 | 18.3 |
| Rice polish | 10.0 | 8.0 |
| Soybean oil | 2.3 | 2.8 |
| Fish meal | 9.1 | 8.3 |
| Di-Ca phosphate | 1.8 | 1.4 |
| Limestone | 1.51 | 1.31 |
| NaCL | 0.5 | 0.5 |
| Choline chloride | 0.1 | 0.1 |
| *Vitamin & Mineral Premix | 0.5 | 0.5 |
| DL-Methionine | 0.1 | 0.1 |
| Lysine sulfate 70% | 0.09 | 0.09 |
| Threonine | 0.1 | 0.1 |
| **Total** | 100 | 100 |
| **Calculated Values (%)** | | |
| ME (Kcal/Kg) | 3001.47 | 3100.88 |
| Crude protein | 22.08 | 20.00 |
| Calcium | 1.003 | 1.003 |
| Inorg. Phosphorus | 0.450 | 0.460 |

*Supplied per kilogram of diet: 10,000 IU of Vitamin A (Retinol), 1,500 IU of Vitamin $D_3$ (Cholecalciferol), 10 mg of Vitamin E (α-tocopheryl acetate), 2.0 mg of Vitamin $K_3$ (Menadione), 1.0 mg of Vitamin $B_1$ (Thiamin), 5.0 mg of Vitamin $B_2$ (Riboflavin), 1.5 mg of Vitamin $B_6$ (Pyridoxine), 0.03 mg of Vitamin $B_{12}$ (Cyanocobalamin), 10 mg of Pantothenic acid, 2.0 mg of Folic acid, 30 mg of Nicotinic acid, and 0.05 mg of Biotin. Additionally, the diet contained 15 mg of Copper (Cu), 2.0 mg of Iodine (I), 50 mg of

Zinc (Zn), 30 mg of Iron (Fe), 60 mg of Manganese (Mn), 0.1 mg of Cobalt (Co), and 0.15 mg of Selenium (Se).

### Brooding of birds

The birds were distributed under the hover for brooding following three different light such as Incandescent light, red LED and white LED. Starting from day one, the chicks were housed in an environment with a temperature of 34°C, which was maintained for the entire first week. After the chicks reached one week of age, the temperature was lowered by 2°C (4°F) each week until it reached 28°C. Lighting for one-day-old birds was maintained at 22 hours per day for the first two days at 20 lux intensity, with 2 hours of darkness. From the third day, the chicks were provided with 18 hours of light and 6 hours of darkness so that the birds could gradually get accustomed to the dark periods. Each experimental shed was mechanically ventilated to eliminate the heat, moisture, carbon dioxide, and ammonia from the birds and ensure a proper environment.

### Vaccination programme

Vaccination was administered to the experimental birds in accordance with their age and vaccination plan. One ampoule of vaccine was reconstituted with distilled water as per the producer's guidelines. The cool vaccination chain for the birds was meticulously maintained until the time of administration. The birds were vaccinated according to the vaccination plan against Newcastle Disease, Infectious Bursal Disease and Infectious Bronchitis.

### Growth performance and carcass characteristics

Live weight gains of broiler chickens were recorded weekly for each replicate using a digital balance. The feed intake (FI) and feed conversion ratio (FCR) were recorded and analyzed throughout each week of the experimental study. The weights of the breast, back, thigh, drumstick, wing, neck and the relative weights of each organ were determined using the following formula:

$$\text{Relative weight} = \frac{\text{Organ weight}}{\text{Live body weight}} \times 100$$

### Recorded parameters

During the rearing and feeding phases of the broiler chicken, data were recorded for the following parameters: feed intake (g), live weight (g), live weight gain (g) and feed conversion ratio. After 28 days, three birds from each replicate were randomly selected and slaughtered to determine carcass weight and dressing percentage.

### Statistical analysis

All recorded data were analyzed using Statistical Package for the Social Sciences (SPSS) 26.0 software. Significant differences among the treatment groups were assessed using a one-way analysis of variance (ANOVA), followed by Duncan's multiple comparison test. The threshold for statistical significance was set at P<0.05, and the standard error of the means was included in the analysis.

## RESULTS

### Effect of different light treatments on production performance

The average live weight of broiler chickens differed significantly across the lighting conditions. Chickens in white LED light group had the highest average live weight followed by those in red LED light group (Table 2). The control group ($T_c$) had the lowest average live weight. This indicates that white LED light promotes the highest live weight in broiler chickens, significantly surpassing both the control and red LED light conditions. Similarly, the average live weight gain was highest in white LED light group followed by red LED light group and the control group. The significant difference between groups suggests that white LED light is most effective in promoting live weight gain in broiler chickens. Although the differences in feed intake among the groups are insignificant (P>0.05), the higher numerical trend suggests a greater feed consumption under white LED light. The cumulative FCR, which is a measure of feed efficiency, was lowest in white LED light group followed by red LED light group and control group. While the differences are not statistically significant, the result indicates a slight improvement in feed efficiency under white LED light conditions. Survivability was highest in the red LED light group with both the control and white LED light groups having slightly lower survivability rates. However, these differences are not statistically significant (P>0.05).

**Table 2.** Effect of different light on production performance of broiler chickens

| Parameters | $T_c$ | $T_r$ | $T_w$ | Mean±SE | P-value |
|---|---|---|---|---|---|
| Average live weight (g) | 1807.36$^c$±14.50 | 1854.38$^b$±30.93 | 1916.84$^a$±16.03 | 1859.52±17.67 | 0.001 |
| Average live weight gain (g) | 1764.37$^c$±15.48 | 1810.38$^b$±30.93 | 1872.84$^a$±16.03 | 1815.85±17.65 | 0.001 |
| Feed intake (g) | 2386.85$^a$±13.86 | 2425.61$^a$±34.51 | 2478.81$^a$±51.80 | 2430.42±22.33 | 0.52 |
| Cumulative FCR | 1.35$^a$± 0.00 | 1.34$^a$±0.01 | 1.32$^a$±0.02 | 1.33±0.01 | 0.06 |
| Survivability | 97.50$^a$±2.50 | 100.00$^a$±0.00 | 97.50$^a$±2.50 | 98.33±1.12 | 0.74 |

Here, $T_c$ = Control, $T_r$ = Red Led, $T_w$ = White Led, Values: Mean ± SE; Means with different superscripts within the same row indicate significant differences (P<0.05), while means with the same superscripts in a row do not show significant differences (P>0.05).

### Effect of different lighting treatments on carcass characteristics

The dressing percentage was significantly highest (P>0.05) in the white LED light group, followed by the red LED light group, with the control group having the lowest dressing percentage (Table 3). This indicates that white LED light positively influences dressing yield compared to red LED and control group. There were no significant differences (P>0.05) was found in breast, thigh, drumstick, wing, neck, liver, heart, and spleen weight. Back, and proventriculus weight showed significant differences across the groups, with the highest weight observed in the white LED light group, followed by the red LED light group, and the control group having the lowest back weight. Interestingly, the control group had a significantly higher gizzard weight than the white LED group, which was higher than the red LED group. Conversely, the red LED group had a significantly higher intestine weight compared to the white LED group, which was higher than the control group.

**Table 3.** Effect of different lighting treatments on carcass yield (g) of broiler chickens

| Parameters | $T_c$ | $T_r$ | $T_w$ | Mean±SE | P-Value |
|---|---|---|---|---|---|
| Dressing percentage | $61.93^c$±0.64 | $62.80^b$±0.54 | $64.51^a$±0.75 | 63.08±0.47 | 0.001 |
| Breast weight | $477.00^a$±10.22 | $497.00^a$±16.67 | $492.75^a$±8.64 | 488.92±6.94 | 0.08 |
| Back weight | $236.25^c$±9.81 | $272.00^b$±8.84 | $287.25^a$±8.76 | 488.92±8.02 | 0.001 |
| Thigh weight | $197.25^a$±2.39 | $210.50^a$±11.73 | $205.25^a$±8.79 | 204.33±4.77 | 0.45 |
| Drumstick weight | $166.00^a$±1.68 | $168.25^a$±16.59 | $175.50^a$±7.93 | 169.92±5.70 | 0.76 |
| Wing weight | $104.50^a$±5.33 | $97.50^a$±4.87 | $107.50^a$±5.04 | 103.17±2.94 | 0.85 |
| Neck weight | $40.75^a$±0.25 | $48.00^a$±4.02 | $45.75^a$±2.39 | 44.83±1.68 | 0.61 |
| Liver weight | $43.25^a$±2.49 | $48.00^a$±5.11 | $45.20^a$±0.86 | 45.58±1.83 | 0.27 |
| Heart weight | $11.25^a$±0.47 | $11.25^a$±0.25 | $45.50^a$±0.64 | 11.00±0.27 | 0.71 |
| Gizzard weight | $33.75^a$±0.85 | $27.00^c$±1.84 | $29.00^b$±1.32 | 28.92±1.26 | 0.005 |
| Proventriculus weight | $7.50^c$±0.28 | $8.00^b$±0.40 | $9.30^a$±0.23 | 8.28±0.28 | 0.001 |
| Spleen weight | $1.70^a$±0.03 | $1.75^a$±0.09 | $1.50^a$±0.11 | 1.69±0.05 | 0.91 |
| Intestine weight | $87.75^c$±2.05 | $144.20^a$±9.31 | $138.50^b$ ±7.13 | 123.42±8.44 | 0.001 |

Here, $T_c$ = Control, $T_r$ = Red Led, $T_w$ = White Led, Values: Mean±SE; Means with different superscripts within the same row indicate significant differences (P<0.05), while means with the same superscripts in a row do not show significant differences (P>0.05).

## DISCUSSION

The results of the current study align with those of Kim *et al.* (2013) and Kumar *et al.* (2017), who found that different colored lights enhanced live weight gain in broiler chickens. On the other hand, the present findings do not support the findings of Rogers *et al.* (2015), who reported that birds reared under LED technology achieved final live weights comparable to those reared under incandescent lighting. Furthermore, the results of the current study contrasted with those of Kumar *et al.* (2017) and Santana *et al.* (2014), who found no relevant differences (P>0.05) in average live weight gain among birds kept under various LED technologies. Additionally, there were no notable differences (P>0.05) in feed intake and feed conversion ratio (FCR) across the different treatment groups. This finding is in agreement with those of Mendes *et al.* (2013), Santana *et al.* (2014), Olanrewaju *et al.* (2015), and Assaf *et al.* (2015), who noted that colored LEDs did not have a significant effect (P>0.05) on average feed intake and FCR when compared to white and incandescent lighting. In contrast, the current findings diverge from those of Fazli *et al.* (2019), who reported that the FCR for the white LED group was significantly lower (P<0.05) than that of the other LED groups. Conversely, the present findings align with those of Kumar *et al.* (2017), who observed no distinct differences (P>0.05) in the weights of the thigh, drumstick, and neck of broiler chickens. However, it contradicts the results of Fazli *et al.* (2019), who noted no substantial differences (P>0.05) in the overall dressing percentage of broiler chickens assigned to various LED light treatments, while indicating significant differences in breast, thigh and wing weights. Notably, limited research exists to definitively establish the impact of light color and source on broiler carcass yield.

## CONCLUSION

The present study revealed that broiler chickens reared under white and red LED lights exhibited improved growth performance compared to those kept under incandescent lighting. This improvement was reflected in increased overall live weight and live weight gain. Carcass yield, except for the back and some internal organs (intestine and gizzard), expressed no significant variation between the groups. Therefore, the white and red LED bulbs evaluated in this study could serve as a better alternative to incandescent bulbs in commercial poultry production, as these LED bulbs can optimize energy efficiency without impairing broiler performance and carcass traits.

### Conflict of interest

The authors declare that they have no conflicts of interest to disclose in relation to this study.

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