Journal of Animal Research: v.7 n.6, p. 1157-1163. December 2017

DOI: 10.5958/2277-940X.2017.00173.5

Performance and Carcass Characteristics of Broiler Chickens reared Under Light Emitting Diodes (LEDs) light *vis-a-vis* Incandescent light Supplemental Lighting Programme

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Received: 17 July, 2017 **Revised:** 15 Sept., 2017 **Accepted:** 20 Sept., 2017

ABSTRACT

Light plays an important role in birds' life hence efforts were made to evaluate the performance of broiler chicken in the open-sided house under light emitting diodes (LEDs) and incandescent bulb lighting programme. For this purpose 240 straight run commercial Vencobb® broiler chicks were procured and distributed in four different light treatment groups i.e. T_w; white (650nm), T_g; green (565nm) and T_b; blue (430nm) light LED bulbs (3 Watt each) and incandescent light bulbs (60 Watt each) as control (T_c) in 12 pens (4×3 factorial design). At the day time open-sided house were open from 10.00 AM to 4.00 PM and rest of the time sides of house were covered with black coloured tarpaulin sheet. Pens were light proof to avoid light interference during dark hours. The results demonstrated that broilers' performance viz. average body weight, average weekly body weight gain, feed intake, feed conversion ratio (FCR), protein efficiency ratio (PER), and energy efficiency ratio (EER) was numerically higher in LED light treatment groups as compared to incandescent light group. Under different light treatments, no significant ($p<0.05$) difference was found on carcass yields (different prime cuts) such as dressing percentage, drumstick, breast, and neck but back and wing weight were significantly ($p<0.05$) different in T_c as compared to T_b and T_w. Carcass quality such as pH, WHC, shear force and instrumental colour were statistically non-significant ($p<0.05$) among different light treatment groups. Therefore, the LED bulbs evaluated in the study could be a better alternative source of light than incandescent light bulbs without affecting broiler performance and carcass characteristics.

Keywords: Light emitting diodes, broiler performance, carcass yield, carcass quality

Poultry farming in India is emerged as the most dynamic and rapidly expanding segment of livestock economy from mere a tool of supplementary income and nutritious food for the family. It has transformed into a commercial activity with the presence of private players, rising market demand, and changing food habits of Indians. Nowadays, the major chunk of poultry production is occurring in intensively managed open sided broiler houses under artificial lighting programme.

There are a number of features (colour, intensity, photoperiod etc.) of the physical light environment in broiler house that may affect broiler birds. Lighting is necessary for the bird's vision, influencing visual acuity and color discrimination (Calvet *et al.,* 2009). Previous studies indicate that light plays a vital role in affecting physiological function and behavior of chickens (Prayitno *et al.,* 1997; Olanrewaju *et al.,* 2006; Kristensen *et al.,* 2007). Further, it has been reported that light manipulation has been an effective measure to improve poultry production (Hassan *et al.,* 2014; Yang *et al.,* 2016).

Conventionally, incandescent bulbs are used in broiler houses for artificial lighting programme, which is less energy efficient and substantially increase the cost of production due to the high cost of electricity (Pereira *et al.,* 2012). The use of LED (light emitting diode) in broiler production has demonstrated high luminous efficiency, less power consumption, and longer service life when compared to incandescent and fluorescent lamps (Cao *et al.,* 2012) but not in vogue in India for artificial lighting programme due to high cost. Government of India has also launched "Domestic Efficient Lighting Programme" on 5 January 2015, for promoting use of LED bulbs in domestic purposes and urging the people to use LED bulbs in place of incandescent bulbs, tube lights and CFL (compact fluorescent light) bulbs to reduce electricity consumption and achieve GHG (green house gas) emission mitigation targets as per the commitment of Kyoto Protocol as most of the electricity in India is being produced using fossil fuels.

There is evidence that use of LEDs in broiler houses may improve broiler productivity reared under environmentally control houses (Rozenboim *et al.,* 2004; Karakaya *et al.,* 2009). However, the information under Indian conditions on the use of LED lights as a source of supplemental lighting in broiler houses along with natural illumination is very limited. Therefore, the present study was planned to evaluate the broilers' performance and carcass characteristics using LEDs lights as a source of supplemental light.

MATERIALS AND METHODS

Bird and broiler house

The present study was conducted on 240 straight run commercial Vencobb® broiler chicks at Poultry Research Farm of the Department of Livestock Production Management, Guru Angad Dev Veterinary and Animal Science University, Ludhiana (INDIA) (Latitude: 30°54' North & Longitude: 75°48' East). This experiment was conducted in the open-sided broiler house comprised of 12 pens (5' × 4' area/pen). Four treatments viz. three different coloured LED bulbs (3 Watt each) Tw; white (650nm), Tg; green (565nm) and Tb; blue (430nm) and incandescent light bulbs (60 Watt each) as control (Tc) was used in the experiment with 3 replicate in each treatment. Out of total 12 such pens, 3 pens/treatment were modified for installation of bulbs. Coloured curtains were placed inside each pen of the house according to the treatment and each pen was completely enclosed to prevent the crossing of light from one treatment to another treatment group. Daytime, the open sided house was open from 10.00 AM to 4.00 PM and rest of the time sides of the house were covered with a black coloured tarpaulin sheet. 23 hour (light): 1 hour (dark) photoperiod was given to broiler birds using both natural and artificial light throughout the experiment period. Light intensity was measured by light intensity meter (Lutron PLX-111 light meter; Range 0-20000 Lux) and maintained at 25 lux in the first week and then reduces successively at a rate of 5 lux per week by increasing the height of bulbs from the bird's eye level. The microclimate of the pens was assessed with the help of dry and wet bulb mercury thermometer and minimum and maximum alcohol thermometer placed on bird head level to ensure that any preferences in each pen occurred due to the light environment and not because of temperature or humidity. Wooden brooders fitted with immersion rods were used for brooding of chicks up to 2 weeks of age.

Broiler chicks were sexed and weighed using electronic balance. These sexed chicks after weighing were randomly distributed to 4 treatment groups each having 3 replicates (20 birds' each-10 male: 10 female).

Feeding and general management

The entire experimental period was divided into 3 phases namely starter (0-2 weeks), grower (3-4 weeks) and finisher (5-6 weeks). The starter, grower and finisher rations were formulated to contain 22, 20 and 18 % crude protein and 2896, 2932 and 2979 Kcal ME/Kg of feed, respectively (Table 1).

Table 1: Ingredient and nutrient composition of rations fed to experimental broiler chicks

Ingredient (%)	Starter (1-2 weeks)	Grower (3-4 weeks)	Finisher (5-6 weeks)
Maize yellow	52.6	58.4	64.6
Soybean meal	39.2	33.4	27.3
Rice polish(oiled)	4.7	4.7	4.9
Dicalcium phosphate	2	2	1.5
Limestone powder	1	1	1.2
Common salt	0.5	0.5	0.5
Additives	+	+	+
Methionine	0.220	0.225	0.210

Calculated Chemical Composition			
CP %	22	20	18
ME, kcal/kg	2896	2932	2979
Lysine %	1.20	1.04	0.89
Methionine%	0.68	0.60	0.53

Additives (per 100 kg): Liver tonic (Superlive TM) 25 g, Vitamin C 15g, Choline chloride 50g, Vitamin A 825000IU, Vitamin D3 165000IU, Vitamin E 500mg, Vitamin B12 2.5g, Vitamin K 100mg, Thiamine 80mg, Riboflavin 6mg, Vitamin B6 160mg, Niacin 1200mg, Biotin 0.2mg, Folic acid 1.0mg, Copper 0.5mg, Iron 4000mg, Manganese 6000mg, Zinc 4600mg, Selenium 10mg, TM_{200} 25mg, Coccidiostat 50mg.

Note: TM_{200} and coccidiostat were applied up to 4 weeks of age only.

Feed was made available *ad-libitum* throughout the experimental period. A weighed quantity of feed was offered two times a day in morning and evening. Waterers were cleaned daily and first few days luke warm drinking water (temperature around 38-40 C) were provided two to three times daily and after that continuous supply of cool and fresh drinking water was ensured during the entire experimental period. The chicks were vaccinated against Marek's, Ranikhet and Infectious Bursal diseases.

Data recording for production traits

The body weight of individual chicks was recorded at weekly intervals with the help of digital weighing balance in early morning prior to feeding and average weekly body weight and average body weight gain were calculated for different treatments groups. Daily each replicate of all the treatment groups was offered a weighed quantity of feed and at the end of every week; feed consumption was calculated by subtracting the residual feed from total feed offered during different days of the week. The average feed intake for each group was calculated by dividing the total feed intake by the number of birds taking into account mortality, if any, in the particular pen. The feed conversion ratio (FCR) in each replicate was calculated by dividing the average feed intake by average weight gain for the week. The Protein efficiency ratio (PER) was calculated as grams of body weight gain per grams of protein consumed and Energy efficiency ratio (EER) was calculated as Kcal of metabolizable energy (ME) consumed per gram of body weight gain. Record of mortality (if any) was maintained on daily basis.

Data recording of carcass traits

At the end of experiment (6th week) nine birds (3 from each replicate) from each treatment were randomly sacrificed using human method of slaughtering. The dressing percentage excluding skin, weight and length of different prime cuts in dressed carcass viz., wings, neck and thorax, breast, back, thigh, and drumsticks were taken for carcass yield. For carcass quality, the pH of raw meat was determined as per the method given by Trout *et al.* (1992) using Elico pH meter (Model LI 127, Elico Limited Hyderabad, India) and the water holding capacity (WHC) by the filter paper press method as modified by Gnanasambandam and Zayas (1992). Shear force was estimated using a texture analyzer (TMS-PRO, Food Technology Corporation, USA) as per the procedure outlined by Bourne (1978). Colour profile was measured using Lovibond Tintometer (Model: RT-300, The Tintometer Limited, Amesbury, UK) set at 2° of cool white light (D65) and known as '*L*', *a*, and *b* values. '*L*' value denotes (brightness 100) or lightness (0), *a* (+redness/–greenness), *b* (+yellowness/–blueness) values.

Statistical analysis

All the data (performance and carcass characteristics) were subjected to statistical analysis using Completely Randomized Design (CRD) and groups were differentiated by one way analysis of variance (ANOVA) utilizing GLM procedure of SAS (SAS® 9.3) software and the difference among various treatments were examined by tukey's test.

RESULTS AND DISCUSSION

Effect of different light treatments on production performance

The average final body weight did not differ significantly ($p<0.05$) among various treatment groups (Table 2). It was evident that the broiler birds are heavier under the LED lamps as compared to the incandescent lamp. The findings of the present study were consistent with the results of Rogers *et al.* (2015), they found that birds raised under

LED technologies grew to final body weights similar to those raised under incandescent light. The result of present study differ from the study of Rozenboim *et al.* (1999), Rozenboim *et al.* (2004), Cao *et al.* (2008) and Kim *et al.* (2013) who found that broiler raised under green-blue coloured LED's light grow better than white and other coloure LED lights and fluorescent lamps, may be because of artificial lighting was used as supplemental lighting and broilers were under natural (solar) light during the day from 10.00 AM to 4.00 PM, and artificial light during the night. Average weekly body weight gain among different treatment groups did not differ significantly ($p \leq 0.05$) and similar results were found by Paixao *et al.* (2011) and Santana *et al.* (2014). The finding of the present study was contrary to the results of Mendes *et al.* (2013) and Rozenboim *et al.* (2004) who reported that colored lights promoted better broiler performance in terms of body weight gain than white light. The results were differing from present study because in both the studies broiler chickens were solely reared under artificial coloured light under environmentally controlled house.

Table 2: Average growth performance parameters of broiler chick under different treatment groups

Treatment/ Parameters	T_c	T_w	T_g	T_b
Average body weight (gm)	1538.20 ± 44.70	1653.60 ± 19.11	1629.86 ± 16.45	1625.13 ± 28.91
Body weight gain (gm)/wk	249.71 ± 34.45	268.61 ± 37.83	264.96 ± 36.79	263.98 ± 37.60
Feed intake (gm)	2942.94 ± 87.05	3021.54 ± 90.99	3040.56 ± 90.61	2959.14 ± 90.33
Cumulative FCR	1.96 ± 0.05	1.87 ± 0.01	1.91 ± 0.01	1.86 ± 0.03
Cumulative PER	2.83 ± 0.08	2.96 ± 0.02	2.90 ± 0.02	2.97 ± 0.05
Cumulative EER	17.15 ± 0.50	17.96 ± 0.16	17.62 ± 0.17	18.04 ± 0.33
Cumulative mortality rate	3.33 ± 0.88	1.66 ± 0.33	2.33 ± 0.33	1.33 ± 0.33

Feed intake among different treatment groups did not differ significantly ($p \leq 0.05$). The overall on an average feed consumption was highest in T_g (3040.56±90.61) group as compare to other treatment groups and was lowest in T_c (2942.94±87.05). This finding is similar in agreement with the findings of Mendes *et al.* (2013), Olanrewaju *et al.* (2015) and Assaf *et al.* (2015) they reported that coloured LEDs (green and blue) did not significantly ($p \leq 0.05$) affect the avg. feed consumption as compared to white and incandescent light. Cumulative feed conversion ratio among different treatment groups did not differ significantly ($p \leq 0.05$), FCR was found lowest in T_b (i.e. 1.86±0.03) as compared to other treatment groups and was highest in T_c (i.e. 1.96±0.05). Lower FCR in LED light treatment groups indicated that efficiency of feed utilization is better in all LED light groups as compared to incandescent light treatment. When LED was used as a light source, cumulative FCR of LED groups ranges between 1.91 to 1.86 at 6 weeks of age which were lower to that of FCR (3.0) obtained by Cao *et al.* (2008) using white LED light; however, the latter evaluated FCR in week 7. The finding of present study is similar in agreement with the findings of Mendes *et al.* (2013), Olanrewaju *et al.* (2016) and Rogers *et al.* (2015) were they found that feed conversion ratio was not affected by the treatments (LEDs and incandescent). Though the result findings are contrary to the findings of Assaf *et al.* (2015) who found that application of green light on the broilers has led to a significant reduction (4.4%, $p>0.05$) in the feed conversion rate for the whole period of fattening compared with white light. The cumulative PER and EER among different treatment groups did not differ significantly ($p \leq 0.05$). The higher PER and EER in the entire test LED groups may be due to more utilization of protein and energy. Mortality among different treatment groups did not differ significantly ($p \leq 0.05$), whereas, mortality rate of broiler chicks was highest in control group (T_c). The findings are similar in agreement with the findings of Mendes *et al.* (2013), Olanrewaju *et al.* (2016), Rogers *et al.* (2015) and Assaf *et al.* (2015) in which mortality were not affected by the treatments.

Effect of different light treatments on carcass characteristics

The mean and standard error of carcass yield and different prime cuts are given in Table 3. Analysis of variance revealed that dressing percentage did not differ significantly ($p \leq 0.05$) among different light treatments. The drum stick yield and length did not differ statistically among the treatments. However, it was highest in LED's groups as compared to control group (T_c). Breast yield and length did not differ significantly ($p \leq 0.05$) among different treatment groups. Though, breast yield was higher in LED light treatment group (T_b>T_w>T_g) as compared to incandescent light where as in different light treatments no any conclusive result was found in breast length. The result finding was similar to the findings of Ke *et al.* (2011) they found that in blue light the yield was more as compared to green, white and red coloured monochromatic light.

Table 3: Effect of different light treatments on carcass yield

Parameter	Carcass Yield			
	T_C	T_w	T_g	T_b
Dressing percentage	59.00 ± 0.53	60.70 ± 0.59	60.10 ± 0.54	62.23 ± 0.30
Drumstick weight (gm)	152.66 ± 7.42	159.66 ± 7.75	160.33 ± 8.37	158.00 ± 7.96
Breast weight (gm)	260.33 ± 11.22	284.00 ± 9.90	279.66 ± 11.24	303.66 ± 15.91
Neck weight (gm)	114.50 ± 11.28	146.33 ± 12.40	145.33 ± 12.18	121.33 ± 18.24
Thigh weight (gm)	165.83 ± 9.86	165.33 ± 12.40	160.00 ± 10.03	168.33 ± 10.59
Back weight (gm)	124.83^{b} ± 5.31	143.33^{ab} ± 4.75	136.66^{ab} ± 6.98	155.66^{a} ± 11.03
Wings weight (gm)	89.50^{b} ± 4.81	105.00^{a} ± 2.23	97.66^{ab} ± 3.69	104.33^{ab} ± 3.48
Drumstick length (cm)	10.90 ± 0.24	10.60 ± 0.21	10.71 ± 0.28	11.05 ± 0.30
Breast length (cm)	15.38 ± 0.55	15.01 ± 0.21	15.38 ± 0.41	16.03 ± 0.46
Neck and thorax length(cm)	13.61 ± 0.79	15.01 ± 0.60	16.18 ± 0.72	15.46 ± 0.88
Thigh length(cm)	8.23 ± 0.27	7.38 ± 0.31	7.40 ± 0.28	8.31 ± 0.31
Back length(cm)	8.35^{c} ± 0.42	8.80^{bcd} ± 0.64	8.10^{bcd} ± 0.65	11.58^{a} ± 1.15
Wings length(cm)	12.65 ± 0.31	13.16 ± 0.47	12.75 ± 0.39	13.71 ± 0.38

Means with different superscripts in a row differ significantly (P<0.05)

Neck and thorax yield and length were also not found statistically significant ($p \leq 0.05$) among different treatment groups. However, in LED treatment groups neck and thorax yield and length was more as compared to control (T_c). The effect of different light treatment on thigh yield and length was found inconclusive. Back yield and length of T_b light treatment group differ significantly ($p \leq 0.05$) with control (T_c). However, no significant difference ($p \leq 0.05$) on back yield and length was found between T_c, T_w and T_g groups. Wings yield of T_w group differ significantly ($p \leq 0.05$) with T_c group but did not statistically different with the other groups. Though, length of wing among different light treatment groups did not differ significantly ($p \leq 0.05$) but the length of wing and wing yield was more in LED groups as compared to incandescent group (T_c). The results of present study is in accordance with the findings of Cao *et al.* (2008) who found that a greater breast and thigh yield for broiler chicken subjected to green-blue, blue-green LED artificial light alterations.

The data on meat quality have been presented in table 4. No significant difference ($p \leq 0.05$) among different light treatment groups was found in meat quality parameters such as pH, water holding capacity, shear force and instrumental colour. The results of present study was similar in agreement with the study of Rakibul Hassan *et al.* (2013) and Ke *et al.* (2011) they found that there was no significant difference ($p \leq 0.05$) on meat quality parameters such as pH, meat colour and shear force under green, blue and white coloured light treatment.

Table 4: Effect of different light treatments on meat quality

Parameters	T_C	T_w	T_g	T_b
pH	6.08 ± 0.04	6.14 ± 0.02	6.26 ± 0.02	6.06 ± 0.10
Water holding capacity	56.66 ± 6.14	53.33 ± 4.21	63.33 ± 6.14	51.66 ± 3.07
Shear force	3.82 ± 0.02	3.80 ± 0.06	3.81 ± 0.02	3.81 ± 0.04
Lightness (L)	50.92 ± 0.33	51.60 ± 0.50	51.81 ± 0.78	50.37 ± 0.56
Redness (a)	0.67 ± 0.05	0.65 ± 0.05	0.64 ± 0.02	0.63 ± 0.02
Yellowness (b)	9.02 ± 0.08	9.03 ± 0.05	9.01 ± 0.12	9.04 ± 0.07

From the present study, it can be concluded that broiler chickens reared under LEDs light treatment groups were better over incandescent light in terms of growth performance by increasing the overall body weight, weekly body weight gain, reducing the FCR, increasing PER and EER. Carcass yield and meat quality among different treatment groups did not differ significantly (p≤ 0.05) apart from back and wing yield. Therefore, the LEDs light bulbs evaluated in this study could be a better alternative light source than incandescent light bulbs for commercial poultry facilities to reduce electricity consumption without affecting the broiler performance and carcass traits.

ACKNOWLEDGEMENTS

The authors thankfully acknowledge the Head, Department of Livestock Production Management for providing necessary support to conduct this experiment and Dean, College of Veterinary and Animal Science, Guru Angad Dev Veterinary and Animal Science University, Ludhiana for financial support for completion of this work.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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