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Performance and Carcass Traits of Broiler Chickens Reared on LEDs vis-a-vis CFL as a Growth Promotor

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ABSTRACT

The present study was conducted to compare the performance of broiler reared under two different light sources and three different light colours. For this purpose, 120, two-week-old IBL-80 (Indian Broiler Ludhiana-80) broiler chicks were randomly distributed in four different treatment groups *viz.* T_{LEDB-G} (first 2 wks, blue LED then switched to green LED for the next 2 wks), T_{LEDG-B} (first 2 wks, green LED then switch to blue LED for the next 2 wks), T_{LEDW} (White LED) and T_{CFL} (CFL light; Control) with 3 replications and 10 birds in each experimental unit was applied. The effects of different lights on performance (BW, BWG and FCR), carcass traits and its economic impact on broiler chickens were investigated in the present study. The results show that performance and carcass traits of broiler birds of blue-green and green blue LED light group was at par to that of CFL group whereas benefit cost ratio of birds of T_{LEDB-G} (1.13) was found highest among different treatment groups. Therefore, use of a combination of monochromatic Blue-Green or Green-Blue LED light could be a better alternative source of light than CFL light in terms of birds' performance, economics and energy saving.

Keywords: Broiler, CFL, LED, performance and carcass traits

In the intensive poultry production system, artificial environmental factors such as temperature, humidity, air velocity, rate of air exchange and light play a significant role in birds' life. Among all these factors, light is one of the important factors essential for the bird's vision. Light not only responsible for visual acuity and colour discrimination (Calvet *et al*., 2009) also have a profound effect on behaviour, physiology and production performance of birds (Pravin *et al*., 2014). 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).

The use of coloured light is an option to enhance broiler growth in the modern broiler industry (Hassan *et al*., 2013) because coloured light modifies the pattern of secretion of hormones related to growth, maturation, and reproduction. Many kinds of light sources are used commercially in poultry production such as incandescent, fluorescent, metal halide, high-pressure sodium, and recently light emitting diodes (LEDs) have been introduced. Light emitting diode (LED) is much more energy efficient and provide adequate illumination as compared to other light sources. However, in Indian conditions, use of coloured LED lights as a source of supplemental lighting in broiler houses with natural illumination is very limited. Therefore, the present study was conducted to compare

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the performance and carcass traits of broiler birds reared under a combination of monochromatic LED lights vis-à-vis CFL light supplemental lighting programme.

MATERIALS AND METHODS

Experimental birds and light treatments

The present study was conducted at the Poultry Research Farm, Department of Livestock Production Management, Guru Angad Dev Veterinary and Animal Science University (GADVASU), Ludhiana (INDIA) (Latitude: 30°54' North & Longitude: 75°48' East).

A total of 120, 14 days old IBL-80 (Indian Broiler Ludhiana-80) broiler chicks with equal sex were taken for the experiment. Initially at the beginning of experiment, day old chicks after sexing (vent sexing) were procured from the university hatchery. Wing bands were applied on the wings of chicks (male: on right and female: on left wing) for identification. First 2 weeks or up to brooding period the chicks were maintained in electric brooder using incandescent bulbs because LED and CFL bulbs do not provide heat. After brooding, the chicks were shifted to an open-sided broiler house comprised of 12 pens (each pen has 5×3 sq. ft. area). Out of total 12 pens, 9 pens were modified for installation of coloured LED bulbs of 5 Watt each (3 pens for white, 3 pens for green and 3 pens for blue LED bulbs) and remaining 3 pens were maintained as such under CFL bulbs (15Watt each) as control. 10 birds (5 male + 5 female) were randomly allotted in each pen. The weight of birds (231.09±3.79 g) was almost equal at the time of allotment in each pen. On 15th day of the experiment, the light of coloured light pens was switched from green to blue (G-B) and blue to green (B-G) light. In the daytime, the open-sided house was open from 9:00 AM to 4:00 PM and the rest of the time sides of the house were covered with the black coloured tarpaulin sheet. Matching colour curtains were placed inside each pen of shed according to light treatment requirement and each pen was completely enclosed to make it light proof. Light intensity and microclimate of the pens was maintained as per the standard practice.

The entire experimental period was divided into 2 periods *viz.* 3-4 weeks and 5-6 weeks. The feed and water were made available *ad-libitum* throughout the experimental period. The chicks were vaccinated as per the vaccination schedule of the Poultry Research Farm of the university.

Performance and carcass components

Body weights and feed intake were determined according to which FCR was calculated for each treatment group. 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.

At the end of the experiment (6th week), six birds (1 male and 1 female from each replicate) from each treatment group were randomly picked and scientifically slaughtered by following standard protocols (humane method). The dressing % and % weight of different prime cuts in dressed carcass viz. wings, neck and thorax, breast, back, thigh, drumsticks, giblet, abdominal fat and offals were taken. For carcass quality traits, a piece of breast muscle from slaughtered birds of all the treatment groups was used. The UpH was determined as per the method given by Trout *et al*. (1992) using Elico pH meter (Model LI 127, Elico Limited, Hyderabad, India), water holding capacity (WHC) by the filter paper press method as modified by Gnanasambandam and Zayas (1992), cooking loss by recording change in product weight before and after cooking and instrumental colour profile of meat sample by using Chroma Meter (Konica Minolta-CR-300) and L^*, a^* and b^* values were recorded. The instrument was calibrated using a white calibration kit supplied with the equipment.

Statistical analysis

All the data (performance and carcass traits) were subjected to statistical analysis using analysis of variance (ANOVA) technique with SAS (SAS® 9.3) software and the difference among the means of different light treatments were examined by Tukey's test.

RESULTS AND DISCUSSION

Effect of different light treatments on production performance

The overall final body weight (BW), body weight gain

Table 1: Effect of supplemental light on broilers' performance

Treatment/ Parameters	Overall/ Sex	T_{CFL}	T_{LEDBG}	T_{LEDGB}	T_{LEDW}
ABW (g)	O	$1586.34^{a} \pm 24.98$	$1577.79^{a} \pm 31.15$	$1527.68^{a} \pm 20.01$	$1482.44^{b} \pm 2.16$
	M	$1645.23^{A} \pm 50.31$	1584.86 ± 34.37	1568.00 ± 37.73	1552.71 ± 77.42
	F	$1495.86^{abB} \pm 41.10$	$1571.20^{a} \pm 37.54$	$1487.36^{ab} \pm 41.92$	$1406.77^{b} \pm 33.8$
AWBG (g)	O	337.53 ± 9.39	336.68 ± 9.15	323.91 ± 7.18	309.68 ± 11.71
	M	355.46 ± 12.89	338.85 ± 16.20	332.07 ± 9.82	325.50 ± 20.24
	F	$320.89^{b} \pm 12.41$	$334.66^{a} \pm 9.77$	$315.76^{b} \pm 10.37$	$292.65^{c} \pm 9.60$
FCR	O	$2.64^{ab} \pm 0.07$	$2.50^{b} \pm 0.05$	$2.72^{a} \pm 0.05$	$2.70^{a} \pm 0.07$
	M	2.50 ± 0.10	2.51 ± 0.09	2.65 ± 0.07	2.62 ± 0.13
	F	2.76 ± 0.10	2.50 ± 0.05	2.80 ± 0.08	2.79 ± 0.08
PER	O	1.93 ± 0.05	2.02 ± 0.04	1.85 ± 0.03	1.89 ± 0.05
	M	2.02 ± 0.07	2.03 ± 0.08	1.90 ± 0.04	1.97 ± 0.10
	F	$1.84^{b} \pm 0.06$	$2.01^{a} \pm 0.04$	$1.80^{b} \pm 0.05$	$1.80^{b} \pm 0.05$
EER	O	13.16 ± 0.34	13.76 ± 0.30	12.64 ± 0.25	12.88 ± 0.40
	M	13.82 ± 0.47	13.83 ± 0.55	12.96 ± 0.33	13.43 ± 0.68
	F	$12.56^{b} \pm 0.45$	$13.70^{a} \pm 0.31$	$12.31^{b} \pm 0.35$	$12.29^{b} \pm 0.34$

(T_{CFL}: Compact fluorescent lamp, T_{LEDBG}: LED blue-green, T_{LEDGB}: LED green-blue, T_{LEDW}: LED white, O: Overall, M: Male, F: Female) (n=30) ^{a,b} Values with a row with different superscripts differ significantly at P<0.05, ^{A,B} Values with a column with different superscripts differ significantly at P<0.05.

(BWG), FCR, PER and EER is presented in Table 1. The overall final body weight (BW) of birds didn't differ significantly among different treatment groups except inT_{LEDW} treatment group where the body weight of birds was significantly (P<0.05) lower as compared to other groups. Broiler chickens are affected by the spectra of light and it was reported that short wavelength spectra (blue, green and UV) of light increase the growth and development of the birds as compared to long wavelength spectra (red) and broad spectra (white) (Cao *et al*., 2008). The CFL bulb produces shorter wavelength, closer to the green and blue light (Mendes *et al*., 2010) whereas white is a homogenous mixture of all colours including red. This may explain why the body weight of broilers submitted to white LED light was lower in the study as compared to green-blue, blue-green LED light and CFL light. Our research finding was consistent with the results of Huth *et al*. (2015), who found that birds raised under LED lights grew to final body weight similar to those raised under CFL light. The result of the present study was not in agreement with the study of Rozenboim *et al*. (1999, 2004), Cao *et al*. (2008) and Kim *et al*. (2013) who found that broiler raised under green and blue coloured LED lights grow better than white and other colour LED lights and fluorescent light. The altered results of the study conceivably because of LED and CFL light was used as a source of supplemental light (only at night) and broilers were under natural day (solar) light during the day time from 09:00 AM to 4:00 PM.

No significant difference was found in body wt. of females in between T_{CFL}, T_{LEDBG} and T_{LEDGB} groups except in case of T_{LEDBG} and T_{LEDW}. However, the final grew up body weight of male and female birds were statistically non-significant when raised under different LED treatments. Though, under exposure to CFL light male chickens presented significantly (P<0.05) higher live weights than female chickens. Our study differs from the findings of Mendes *et al*. (2013), who found that final live weight was not significantly different between sexes for birds raised under the CFL and white LED bulbs.

Overall average weekly body weight gain (AWBG) among the different treatment groups did not differ significantly (P<0.05) and similar results were found by Paixao *et*

Table 2: Effect of different light treatments on carcass yield

Parameters	Overall/ Sex	Carcass yield			
		T_{CFL}	T_{LEDBG}	T_{LEDGB}	T_{LEDW}
Fasting b. wt.	O	1709.00 ± 34.83	1689.00 ± 66.86	1635.00 ± 48.66	1583.67 ± 102.37
	M	1718.67 ± 68.37	1734.00 ± 125.92	1740.00 ± 96.62	1749.33 ± 109.33
	F	1699.33^{a} ± 36.00	1644.33^{ab} ± 66.84	1530.00^{ab} ± 27.05	1418.00^{b} ± 114.00
Dressing %	O	62.16 ± 1.22	61.72 ± 0.98	62.94 ± 1.24	62.40 ± 0.69
	M	60.50 ± 1.62	63.26 ± 0.47	63.79 ± 2.47	63.08 ± 0.49
	F	63.83 ± 1.75	60.18 ± 1.49	62.08 ± 0.94	61.70 ± 1.29
Breast wt.*	O	18.55^{a} ± 0.85	17.43^{ab} ± 0.53	17.68^{ab} ± 0.36	15.78^{b} ± 1.03
	M	18.30 ± 1.61	16.99 ± 0.85	17.86 ± 0.48	15.01 ± 0.66
	F	18.79 ± 0.97	17.87 ± 0.69	17.49 ± 0.62	16.54 ± 1.09
Drumstick wt.*	O	11.08 ± 0.46	11.22 ± 0.45	10.56 ± 0.46	10.60 ± 0.29
	M	11.90 ± 0.53	11.90 ± 0.71	11.06 ± 0.49	10.98 ± 0.38
	F	10.27 ± 0.33	10.54 ± 0.25	10.06 ± 0.76	10.22 ± 0.37
Thigh wt.*	O	11.31^{a} ± 0.31	10.80^{a} ± 0.33	10.73^{a} ± 0.38	9.91^{b} ± 0.17
	M	11.86^{a} ± 0.22	11.01^{ab} ± 0.57	10.59^{b} ± 0.52	10.76^{b} ± 0.19
	F	10.76 ± 0.50	10.59 ± 0.42	9.89 ± 0.17	10.06 ± 0.29
Back wt.*	O	9.95 ± 0.64	10.39 ± 0.23	9.98 ± 0.45	9.52 ± 0.67
	M	8.93 ± 0.34	10.69 ± 0.34	9.08 ± 0.47	9.37 ± 0.73
	F	9.96 ± 1.29	10.08 ± 0.24	10.07 ± 0.16	9.95 ± 1.05
Wing wt.*	O	7.74 ± 0.74	7.36 ± 0.21	6.69 ± 0.26	6.56 ± 0.24
	M	8.80^{a} ± 0.25	7.43^{ab} ± 0.40	6.99^{b} ± 0.44	6.48^{b} ± 0.23
	F	9.68^{a} ± 0.21	7.29^{ab} ± 0.24	6.40^{b} ± 0.24	6.64^{b} ± 0.47
Giblet wt.*	O	7.66 ± 0.30	7.13 ± 0.23	7.08 ± 0.28	7.55 ± 0.20
	M	7.30 ± 0.23	7.32 ± 0.38	6.72 ± 0.02	7.43 ± 0.30
	F	7.16 ± 0.27	7.07 ± 0.26	7.44 ± 0.52	7.68 ± 0.32
Neck & thorax wt.*	O	10.79 ± 0.87	10.05 ± 0.63	11.04 ± 0.38	10.76 ± 0.44
	M	10.88 ± 0.36	10.59 ± 0.40	10.87 ± 0.52	11.00 ± 0.31
	F	11.69 ± 1.57	10.51 ± 0.84	11.20 ± 0.66	10.86 ± 0.29
Abdominal Fat*	O	2.54 ± 0.33	2.17 ± 0.35	2.20 ± 0.57	2.78 ± 0.58
	M	2.62 ± 0.41	2.08 ± 0.44	2.11 ± 0.15	1.95 ± 0.28
	F	2.45 ± 0.45	2.26 ± 0.38	3.00 ± 1.00	3.62 ± 0.97
Offals wt.*	O	22.99 ± 0.57	22.52 ± 0.73	21.92 ± 1.06	23.30 ± 0.64
	M	21.45 ± 0.62	23.45 ± 1.25	21.73 ± 1.86	22.87 ± 0.39
	F	20.52 ± 1.01	21.58 ± 1.62	22.10 ± 1.46	23.73 ± 1.31

(T_{CFL}: Compact fluorescent lamp, T_{LEDBG}: LED blue-green, T_{LEDGB} : LED green-blue, T_{LEDW} : LED white, O: Overall, M: Male, F: Female) (n=6)*Percent of dressed carcass, ^{a,b} Values with a row with different superscripts differ significantly at $P<0.05$.

Table 3: Effect of different light treatments on meat quality

Parameters	Overall/Sex	T_{CFL}	T_{LEDBG}	T_{LEDGB}	T_{LEDW}
UpH	O	5.83 ± 0.28	5.80 ± 0.03	5.68 ± 0.06	5.80 ± 0.05
	M	5.85 ± 0.00	5.83 ± 0.06	5.67 ± 0.13	5.79 ± 0.10
	F	5.81 ± 0.06	5.77 ± 0.05	5.69 ± 0.05	5.81 ± 0.07
WHC (%)	O	32.25 ± 1.07	35.41 ± 2.23	36.41 ± 2.87	33.50 ± 2.01
	M	32.27 ± 2.11	36.61 ± 4.64	39.66 ± 5.17	35.00 ± 4.17
	F	32.22 ± 1.12	34.22 ± 1.39	33.16 ± 2.00	32.00 ± 0.83
Lightness	O	49.04^{a} ± 2.43	47.25^{ab} ± 2.40	43.90^{ab} ± 2.31	40.54^{b} ± 1.32
(L*)	M	46.00 ± 2.45	47.43 ± 4.59	43.09 ± 4.59	39.44 ± 2.56
	F	52.07^{a} ± 3.80	47.07^{ab} ± 2.80	44.70^{ab} ± 2.97	41.65^{b} ± 0.97
Redness	O	6.17 ± 1.06	9.60 ± 3.27	8.84 ± 1.11	8.02 ± 0.88
(a*)	M	6.90 ± 2.02	12.64 ± 6.25	8.20 ± 1.39	8.75 ± 1.81
	F	5.43 ± 1.03	6.56 ± 2.30	9.49 ± 1.95	7.29 ± 0.30
Yellowness (b*)	O	7.29 ± 1.24	5.92 ± 0.79	8.08 ± 1.05	6.08 ± 0.50
	M	6.80 ± 2.42	5.65 ± 0.22	6.52 ± 1.02	6.00 ± 1.00
	F	7.78 ± 1.26	6.20 ± 1.74	9.64 ± 1.45	6.16 ± 0.48
Cooking loss (%)	O	19.16 ± 0.01	19.16 ± 0.01	19.17 ± 0.00	19.16 ± 0.00
	M	19.18 ± 0.02	19.15 ± 0.02	19.17 ± 0.01	19.16 ± 0.00
	F	19.14 ± 0.00	19.16 ± 0.01	19.16 ± 0.01	19.16 ± 0.01

(T_{CFL}: Compact fluorescent lamp, T_{LEDBG}: LED blue-green, T_{LEDGB}: LED green-blue, T_{LEDW}: LED white, O: Overall, M: Male, F: Female) (n=6), ^{a,b} Values with a row with different superscripts differ significantly at P<0.05.

al. (2011), Kim *et al*. (2013), Mendes *et al*. (2013) and Santana *et al*. (2014). The finding of the present study was contrary to the results of Rozenboim *et al*. (2004) who reported that different coloured lights promoted better growth in broiler chicken in terms of body weight gain than white light.

However, the average weekly body weight gain of female birds of T_{CFL} had a significant (P<0.05) difference from birds of T_{LEDBG} and T_{LEDW} group. The AWBG of female birds of T_{LEDW} was found minimum among the female birds of different groups.

The FCR of T_{LEDBG} group was significantly (P<0.05) lower among different LED treatment groups. Though the FCR of birds reared under CFL and T_{LEDBG} group did not differ significantly (P< 0.05). The FCR of birds of T_{CFL} group was in between the birds of T_{LEDBG}, T_{LEDGB} and T_{LEDW} group. However, no particular previously reported set pattern was found in the FCR of different treatment groups. The results are in agreement with various studies in which light source alone did not significantly influence the feed intake in birds (Huth and Archer, 2015; Olanrewaju *et al*., 2016). Kumar *et al*. (2017) reported that the FCR of broiler chicken grew on LED technologies had numerically lower FCR as compared incandescent lamp. The result findings are contrary to the findings of Sultana *et al*. (2013) and Assaf *et al*. (2015) who found that application of green and blue light on the broilers has led to a significant reduction in feed conversion rate compared with white light because green and blue light caused birds to rest more. This extra resting could have resulted in improved FCR. No significant difference was found in overall PER and EER of birds of different treatment groups. Though, overall PER and EER of T_{LEDBG} were numerically higher as compared to other treatment groups.

PER and EER of female birds of T_{LEDBG} group were significantly (P<0.05) different from the other treatment groups because of the fact that birds of T_{LEDBG} group utilized protein in a better way as compared to other treatment groups.

Effect of different light treatments on carcass traits

At 42nd day of the experiment, when birds were slaughtered, no significant difference was observed in the overall dressing % and cut yield. However, for breast yield and thigh yield, statistical differences were noted among CFL and white LED group (Table 2). Significantly ($P<0.05$) higher thigh + wing yield of male birds and wing yield of female birds were found in T_{CFL} as compared to green-blue and white LED groups. The results of the present study are in accordance with the findings of De *et al*. (2014), who found no significant difference in carcass yield and cut yield of broiler chickens exposed to different LED colours compared with fluorescent lamps. Leigh *et al*. (2017) reported similar results when birds were reared under different coloured LED lights (white, green blue and red) with minor differences in wing yield and minor pectoralis yield. However, very few studies were conducted to support the effect of colour and source of light on carcass yield.

The mean and standard error of mean of carcass quality traits such as UpH, WHC, instrumental colour, and cooking loss under different light treatment groups is presented in table 3. The result of the study is similar with the study conducted by Kumar *et al*. (2017), Hassan *et al*. (2013) and Ke *et al*. (2011).

Economics of broiler production

The data on economic analysis have been presented in table 4. In the study, net income/broiler chicken was highest in T_{LEDBG} i.e. ₹ 15.89 followed by ₹ 8.95 in T_{LEDW}, ₹ 6.62 in T_{LEDGB} and ₹ 6.22 in T_{CFL} group. The benefit-cost ratio in T_{CFL}, T_{LEDBG}, T_{LEDGB} and T_{LEDW} was 1.05, 1.13, 1.05 and 1.08 respectively. Net income/bird was observed higher

Table 4: Economics of broiler production

Particulars	T_{CFL}	T_{LEDBG}	T_{LEDGB}	T_{LEDW}
Cost of production (₹)				
Total installation cost of light bulbs (₹)	360	330	330	330
Total fixed expenditure (₹) (based on avg. life of bulbs)	28.56	5.23	5.23	5.23
Total fixed expenditure (₹/birds)	0.95	0.17	0.17	0.17
Total operational cost (electrical units consumed × per unit price)	135.1 (19.3× 7)	44.31 (6.33 ×7)	44.31 (6.33 ×7)	44.31 (6.33 × 7)
Operational cost (₹/bird)	4.5	1.47	1.47	1.47
Expenditure on brooding (₹/bird)	9.7	9.7	9.7	9.7
Chick price (₹/bird)	12	12	12	12
Medication and vaccination (₹/bird)	5	5	5	5
Feeding cost (₹/bird)	94.82	89.81	94.82	88.68
Total working cost (3+5+6+7+8+9) (₹/bird)	126.97	118.15	123.16	117.02
Output (₹)				
Average body weight/bird (gm)	1586.34	1577.79	1527.68	1482.44
Market price of bird per kg live b.wt. (₹)	85	85	85	85
Gross return from sale of live bird (₹/bird)	134.3	133.45	129.2	125.8
Income (₹)				
Net income from sale of live bird (₹/bird)	6.22	15.89	6.63	8.95
Benefit – Cost Ratio	1.05:1	1.13:1	1.05:1	1.08:1

(T_{CFL}: Compact fluorescent lamp, T_{LEDBG}: LED blue-green, T_{LEDGB}: LED green-blue, T_{LEDW}: LED white).

in LED light treatment groups as compared to CFL group. The present findings were in accordance with the findings of Kumar *et al*. (2017), who also found that net profit/bird was higher in LED light treatment groups as compared to the incandescent group. Higher profitability in LED groups is due to reduced consumption of electricity, which directly affects working cost in broiler rearing.

CONCLUSION

It can be concluded that broiler chickens reared under a combination of monochromatic LEDs light group blue-green or green-blue perform at par or even better with that of birds reared under CFL light in terms of growth performance, carcass traits and economics without any detrimental effect. Therefore, blue-green LED combinations under Indian conditions could be a better alternative light source than CFL light for commercial poultry facilities to reduce electricity consumption without affecting the broiler performance.

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ETHICAL STATEMENT

All the procedures were reviewed and approved by the Institutional Animal Ethics Committee, GADVASU, Ludhiana (INDIA). (GADVASU/2017/IAEC/41/14)

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