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Growth performance of broiler chicken under colour light

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Abstract
The study was conducted to assess the effect of colour light (green, λ= 560 nm; blue, λ= 480 nm; red, λ= 660 nm) on growth of broiler chicken and compare it with growth rate under white LED light and incandescent bulb light. Weekly body weight gain and relative expression of *IGF-1* gene in breast muscle at 17, 24 and 31-day of growth were used to measure the growth. The study showed that the body weight gain of two-week-old broiler chicks under green, blue and white light were higher compared to birds under incandescent light. Third-, fourth- and fifth-week body weight gain of birds in blue and green light was better than the birds under other lights used, with maximum gain in birds under blue light. The study showed that on day 17 the birds under green light had more *IGF-1* expression, followed by those under blue light. On day 24 and 31 birds reared under blue light showed a better *IGF-1* gene expression than others. In the early period up to day 17, green light was most stimulatory to growth and the expression of *IGF-1* gene under study. After day 17 up to day 31, blue light resulted in maximum expression of *IGF-1* gene and growth. The study revealed that blue and green monochromatic LED light is better for growth of broiler chicken than incandescent, white and red light. The birds under incandescent light had lowest performance.

Keywords: IGF-1, body weight gain, light colour, broiler chicken

1. Introduction
Broiler production is one of the most dynamic and fastest growing animal husbandry sub-sectors in India with around 11 per cent growth rate per annum. The transition from backyard to commercial poultry production has resulted in the rearing of chickens in large barns or brooder houses which require intensive management. The impact of light on both avian physiology and behaviour depends on: intensity, photoperiod and wavelength. Wavelength has a critical impact on poultry production and physiology and has become a recent topic of interest.

Results of the available studies looking at spectral composition were inconsistent mainly because the incandescent and fluorescent lamps used earlier produced coloured light with a range of spectrum. LED bulbs are now available in the market which can give monochromatic light. Hence, the present study was undertaken to scientifically evaluate the beneficial and harmful effects of monochromatic base colour light on growth of broiler chicken based on the assessment of the relative expression of *IGF-1* gene in breast muscle and the weekly body weight gain on exposure to red, blue and green monochromatic light as well as white LED and incandescent light.

2. Materials and Methods
2.1 Experimental animals
The experiment was carried out summer season using one hundred and fifty, day old Vencobb broiler chicks, for a period of 35 days. After 10 days of brooding period, the birds were randomly divided into five groups and artificial light with a minimum of 5 lux was provided from 6pm to 6am; as mentioned below;

Table 1: Groups allotted to a particular light treatment

Group	Type of light
Group 1 (G1)	Light from ordinary incandescent bulb
Group 2 (G2)	White light with LED bulb
Group 3 (G3)	Blue light with LED bulb
Group 4 (G4)	Green light with LED bulb
Group 5 (G5)	Red light with LED bulb

Each treatment was replicated thrice with 10 birds in each replicate.

Six birds (Two birds from each replicate) were euthanized from each group on day 17, 24 and 31. All birds had free and *ad libitum* access to feed and water.

Samples of breast muscle were collected and preserved for *IGF-1* gene expression studies as per the standard protocol (Livak and Schmittgen, 2001) [6].

2.2 Isolation of RNA

The total RNA was isolated manually using TRI reagent (Origin) according to the instructions of manufacturer with slight modification.

2.3 Synthesis of cDNA

The total RNA was reverse transcribed into cDNA using cDNA synthesis kit with RNase inhibitor (Origin, ODR41) as per manufacturer's protocol using random hexamer primers. Primers were designed using online NCBI primer design software (Primer3, http://bioinfo.ut.ee/primer3/).

Table 2: Primer details

Gene	Primers	Sequence (5'-3')	Product size
IGF-1 (Target)	Forward	5' GCTCCAATAAAGCCACCTAAATC 3'	125 bp
	Reverse	5' TAGTTTCTGTTTCCTGTGTTCCC 3'	
HPRT (Housekeeping)	Forward	5' CAATCCAAAGATGGTGAAAGTGG 3'	121 bp
	Reverse	5' GAGGGCGTATCCAACAACAAA 3'	

2.4 Quantitative real-time PCR (qRT-PCR)

Real-time PCR was performed using 2X Real-Time PCR Master Mix (final 2.5 mM $MgCl_2$), including SYBR Green (Origin) as per manufactures instructions with slight modification. Relative quantification was performed by $2^{-\Delta\Delta C}{}_T$ method (Pfaffl, 2001) [3]. For treatment wise comparison of the tissue samples incandescent light treatment was selected as the control.

2.5 Body Weight Gain

Body weight gain of the birds was recorded at weekly intervals, up to day 35 of age, to study the pattern of growth under five light treatments.

Statistical comparison between samples was performed using two-way ANOVA (Analysis of variance) followed by Duncan's multiple range test (p-value of ≤ 0.05 was considered statistically significant).

3. Results and Discussion

3.1 Effect of Light: Treatment on Relative Expression of Insulin like Growth Factor-1 (IGF-1) Gene in Broiler Chicken

Table 3: Relative expression profile of insulin like growth factor-1 gene in breast muscle of 17, 24 and 31-day old chicken under different light. Mean ± SE (n=6)

Treatment	*Fold change from control ($2^{-\Delta\Delta C_T}$)*		
	D17	*D24*	*D31*
White	1.84±0.65 [a]	1.02±0.20 [a]	1.83±0.60 [ab]
Green	13.9±1.80 [c]	2.39±0.81 [a]	5.72±2.04 [ab]
Blue	5.21±2.93 [b]	10.3±1.75 [b]	10.62±2.93 [b]
Red	1.12±0.79 [a]	1.27±0.34 [a]	1.68±0.27 [a]

a, b, c Means within a column with no common superscripts are significantly different at 5% level

It was noticed that on day 17, the birds under green light had a significantly ($p \leq 0.05$) high *IGF-1* gene expression than all other group of birds, followed by birds under blue light. Bai *et al.* (2016) [1] reported that the *IGF-1R* mRNA level of gastrocnemius and pectoral muscles and circulating IGF-1 level were highest from 1 to 10 days post-hatch in chicks which were exposed to green light *in-ovo* compared to chicks exposed to blue, red, white light or darkness. According to Wang *et al.* (2017) [7] at day 17 and 20 of embryogenesis, the plasma IGF-1 was higher in chicks from green light exposed group compared to birds exposed to blue, white, red light or darkness. In the present study, it was seen that exposure to green LED light enhanced the *IGF-1* gene expression of breast muscle during the initial growing period of birds from day 11 to 17. There is scope of further study for finding out the molecular path way by which green light produces better *IGF-1* expression during the early post hatch period of day 11-17.

On day 24 and 31, birds under blue light (G3) showed a significantly ($p \leq 0.05$) better *IGF-1* gene expression than others. No previous reports are available to compare the result of the present study. On day 24 and 31, the breast and thigh muscle fibre diameter of birds reared under blue light was highest, which indicate a better growth under blue light.

3.2 Effect of Light Treatment on Body Weight Gain

The body weight gain of two-week-old broiler chicks under green, blue and white light were significantly ($p \leq 0.05$) high compared to birds under incandescent light. Rozenboim *et al.* (1999) [4] reported that the body weight gain of birds exposed to blue and green light was more compared to chicken in red and white light groups.

Third-, fourth- and fifth-week body weight gain of birds in blue and green light was better than the birds under other lights used, with maximum gain in birds under blue light. Rozenboim *et al.* (2004) [5] in their study demonstrated that the growth of chicks reared under blue light was best stimulated from 10 to 46 days of age compared to chicks reared under incandescent light. The present study revealed similar results. Halevy *et al.* (1998) [2], reported that, on day 35 the number of satellite cells per gram of breast muscle was greater in chicks kept in green light, while blue light exposed chicks had higher satellite cells in total. As satellite cells are a member of the myoblast family, this may be the mechanism by which blue and green light might stimulate muscle growth and corresponding elevation in body weight gain. Present study shows that blue and green light can stimulate growth through enhancing the activity of *IGF-1* gene too.

Table 4: Effect of light treatments on the body weight gain of broiler chicken, Mean ± SE (n=6)

Treatment	Body weight gain (g)			
	Period (weeks)			
	2	3	4	5
Incandescent	291.17 ±25.39 ^{ax}	362.17± 38.44 ^{ax}	479.83 ±37.99 ^{bx}	389.67±28.20 ^{abx}
White	353.83±7.12^{ay}	416.67±13.36 ^{bxy}	494.83±20.30 ^{cx}	415.67±16.02 ^{bxy}
Green	356.67±8.35$^{a\ y}$	459.33±8.82 ^{by}	583.17±22.36 ^{cxy}	502.33±27.92^{bz}
Blue	355.67±28.20 ^{ay}	459.67±32.78 ^{aby}	626.33±48.33 ^{cy}	484.50±46.66 ^{bz}
Red	342.17±15.32^{axy}	413.67±19.64 ^{abxy}	514.83±33.80 ^{bx}	440.83±56.41 ^{aby}

a, b, c, d, e Means within a row with no common superscripts are significantly different at 5% level.
x, y, z Means within a column with no common superscripts are significantly different at 5% level.

4. Conclusions

Light colour affected weekly body weight gain and the relative expression of *IGF-1* gene. The body weight gain of two-week-old broiler chicks under green, blue and white light were higher compared to birds under incandescent light. Third-, fourth- and fifth-week body weight gain of birds in blue and green light was better than the birds under other lights used, with maximum gain in birds under blue light. The study also showed that on day 17 the birds under green light had more *IGF-1* expression than all other group of birds, followed by those under blue light. On day 24 and 31 birds reared under blue light had better *IGF-1* gene expression than others. In the early period up to day 17, green light was most stimulatory to growth and the expression of *IGF-1* gene. After day 17 up to day 31, exposure to blue light resulted in the maximum expression of *IGF-1* and growth. The study revealed that blue and green monochromatic LED light is better for growth of broiler chicken than other lights used. It can be concluded that chicken can be reared under green light up to day 17 and then afterwards under blue light for more growth. However, more studies are required with these light combinations (Green light up to day 17 post hatch and blue thereafter) to elucidate the exact effect of the combination on growth.

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