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Effect of exposure to monochromatic light on breast and thigh muscle fibre diameter of broiler chicken

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Abstract
The study was conducted to evaluate the effect of different LED monochromatic light (green, λ= 560nm; blue, λ= 480nm; red, λ= 660nm) on breast and thigh muscle fibre diameter of broiler chicken in comparison with white LED light and incandescent bulb light. Muscle fibre diameter of breast and thigh muscle of 17, 24 and 31 day old broiler chicks was assessed. The study showed that on day 17, the birds reared under green and blue light had a better breast and thigh muscle fibre diameter. On day 24 and 31, birds reared under blue light showed a better breast and thigh muscle fibre diameter than others. The study revealed that blue and green monochromatic LED light is better for the breast and thigh muscle fibre development of broiler chicken than other lights used.

Keywords: Muscle fibre diameter-growth-broilers-production

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. Due to increasing population growth, urbanization and rising income there is an increasing demand of animal protein source so that chicken meat has shown its fastest growth in last two decades.
The transition from barnyard to commercial poultry production has resulted in the rearing of chickens in large barns or brooder houses which require intensive management. To facilitate production, producers are capable of manipulating and modulating environmental parameters such as temperature, humidity, ventilation, gases, light intensity, light duration and light colour. Of these factors, light may be the most critical for chickens as it controls many physiological and behavioral processes (Olanrewaju *et al*., 2006).
The impact of light on both avian physiology and behaviour depends on: intensity, photoperiod and wavelength. The effects of light intensity and photoperiod were well studied and efficiently utilized by the poultry farmers. Wavelength also has a critical impact on poultry production and physiology and has become a recent topic of interest. Domestic fowl have well-developed colour vision that is superior to humans. They are capable of sensing ultraviolet, blue, green and red in the light spectrum (Prescott and Watches, 1999) via retinal and deep brain photoreceptors (Kuenzel *et al*. 2015).
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. The heatless nature of LED bulbs may also reduce heat stress. *In-ovo* exposure to monochromatic light during incubation resulted in upregulation of myogenic gene and better muscle development in broilers (Bai *et al.*, 2016). However, no reports are available on the effect of monochromatic light during post-hatch growing period. Hence, the present study was undertaken to scientifically evaluate the beneficial and harmful effects of monochromatic light on growth of broiler chicken based on the assessment of the muscle fibre diameter of breast and thigh muscle on exposure to red, blue and green monochromatic light as well as white LED and incandescent light.

Materials And Methods
The experiment was carried out for a period of 30 days in summer season. One hundred and fifty, day old Vencobb broiler chicks, were procured from Venkateswara Hatchery Ltd, Palakkad and were used for the study. After 10 days of brooding, the birds were randomly

divided into five groups. There were three replicates for each group with 10 birds in each replicate. Among all the groups, average body weight of the birds were made as uniform as possible. All the birds were provided with *ad libitum* standard broiler feed, water and identical photoperiod. 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 (I) bulb
Group 2 (G2)	White (W) light with LED bulb
Group 3 (G3)	Blue (B) light with LED bulb
Group 4 (G4)	Green (G) light with LED bulb
Group 5 (G5)	Red (R) light with LED bulb

Two birds were euthanized from each replicate on 17, 24 and 31 days of age.

Samples of breast and thigh muscles were collected and muscle fiber diameter was estimated as per the method of Jeremiah and Martin, 1977.

Tissue samples of breast and thigh muscle (approximately 5 g each) were collected from 6 chickens in each group, packed in High Density Poly Ethylene (HDPE) pouches and aged for 72 h at 2-4ºC (Samsung Digital Inverter Technology, India). The muscle in high-density polyethylene (HDPE) pouches were transferred to deep freezer and maintained at -20ºC until further analysis. Within one week of freezer storage, meat was thawed at 4±1ºC for 12 h before assessment of the muscle fiber diameter.

Five grams of meat sample from breast and thigh muscles were cut into small pieces and homogenized into a slurry, in a solution containing 0.25 M sucrose and one mM EDTA, with a domestic mixer grinder twice for 15 seconds at low speed, interspaced with an interval of five seconds. One or two drops of the slurry was transferred into a microscopic slide and covered with a cover slip. The meat slurry was examined directly under Trinocular Research microscope (Leica DM 2000 LED, Germany) equipped with 20X objective eye piece under 100 micrometer calibration scale. Muscle fibre diameter was measured as the mean cross-sectional distance between exterior surfaces of sarcolemmae of randomly selected muscle fibres and expressed in micrometre (µm).

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).

Results and Discussion

Breast and thigh muscle fibre diameter of control and treatment groups of birds are presented in table 2 and figure 1. On day 17, breast muscle fibre diameter of birds reared under green light was significantly (P≤0.05) high when compared to birds reared under incandescent, white and red light. On day 17, the thigh muscle fibre diameter was significantly (P≤0.05) high in chicks reared under green as well as blue light compared to chicks reared under incandescent, white and red light. Rozenboim *et al.* (1999) reported that green and blue LED light illumination to broilers resulted in enhanced breast muscle weight at 23 and 34 days of age compared to broilers reared under white and red LED light. Cao *et al.* (2008) revealed that, at day 21, the pectoral myofiber area of birds reared under green light was largest compared to birds reared under red, blue, and white light. Zhang *et al.* (2014) reported that the cross-sectional area of myofiber from pectoral muscle was significantly high in 7-day-old chicks which were exposed *in-ovo* to green light compared to that of the chicks exposed *in-ovo* to dark condition. Bai *et al.* (2016) reported that 1 to 10 day old chicks which were exposed *in-ovo* to green light had larger pectoral and gastrocnemius muscle fibers and higher proliferative activity of satellite cells when compared to chicks exposed *in-ovo* to blue, white, red light or darkness. Wang *et al.* (2017) revealed that at day 17 and 20 of embryogenesis, the pectoral and gasterocnemius muscle fiber size and the proliferation of satellite cells were higher in chick embryos exposed *in-ovo* to green light compared to chick embryos exposed *in-ovo* to blue, white, red light or darkness. In the present study, it was seen that exposure to green LED light enhanced the breast and thigh muscle fibre diameter during the initial growing period of birds up to day 17. Green light promoted growth of myofiber which was probably due to the proliferation of skeletal muscle satellite cells (Cao *et al*., 2008).

On day 24, the breast muscle fibre diameter of birds reared under blue light was significantly (P≤0.05) high in comparison to the birds reared under incandescent, white and red light. On day 24, blue light treated birds had a significantly (P≤0.05) high thigh muscle fibre diameter compared to birds reared under incandescent, white, green and red light. The breast muscle fibre diameter of 31 day old birds reared under blue light was significantly (P≤0.05) high compared to birds reared under incandescent, white, green and red light. The thigh muscle fibre diameter of 31 day old birds was significantly (P≤0.05) high in birds under blue light compared to those under incandescent, white, and red light. Cao *et al.* (2008) revealed that on day 49, the pectoral myofiber area of birds reared under blue light was the largest, and it was larger than that of birds reared under white, red and green light. In the present study, it was seen that exposure to blue LED light enhanced the breast and thigh muscle fibre diameter during the late growing period of birds at day 24 and 31.

The increased muscle fibre diameter observed in blue and green group of birds might be due to the increased secretion of testosterone in these groups of birds (Cao *et al*., 2008).

A significant (P≤0.05) increase in muscle fibre diameter of breast as well as thigh muscle was noticed from day 17 to day 31 in all the group of birds under study.

Table 2 Effect of light treatments on the breast and thigh muscle fibre diameter of broiler chicken. Mean ± SE (n=6)

Treatment	Muscle fibre diameter (µm)					
	Breast muscle			Thigh muscle		
	Days of age			Days of age		
	17th day	24th day	31st day	17th day	24th day	31st day
I	21.22 ± 0.42 ax	37.63 ± 0.27 ay	46.88 ± 0.14 az	21.13 ± 0.29 ax	37.40 ± 0.09 ay	47.07 ± 0.09 az
W	21.39 ± 0.68 ax	38.03 ± 0.23 aby	46.90 ± 0.12 az	21.17 ± 0.21 ax	38.17 ± 0.17 by	47.15 ± 0.07 abz
G	23.75 ± 0.52 bx	38.52 ± 0.16 bcy	47.47 ± 0.12 bz	23.63 ± 0.44 bx	38.27 ± 0.06 by	47.32 ± 0.04 bcz
B	23.28 ± 0.67 abx	39.18 ± 0.16 cy	47.88 ± 0.09 cz	22.77 ± 0.31 bx	38.83 ± 0.15 cy	47.65 ± 0.10 cz
R	21.63 ± 0.86 ax	38.13 ± 0.29 aby	47.02 ± 0.13 az	21.25 ± 0.29 ax	38.10 ± 0.25 by	47.22 ± 0.03 abz

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

Conclusion

The present study revealed that light colour effected muscle fibre diameter of breast and thigh muscles. In the early period that is up to day 17, green light was found better for the breast and thigh muscle development. From day 17 till day 31, blue light resulted in maximum breast and thigh muscle fibre diameter. Therefore, 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 during same period. The study revealed that blue and green monochromatic LED light is better for increasing the breast and thigh muscle fibre diameter of broiler chicken compared to other lights used.

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