IMPACT OF LED (LIGHT EMITTING DIODE) TUBES ARTIFICIAL LIGHTING SYSTEM ON BROILER PRODUCTION

A Thesis

By

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A Thesis

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*This is to certify that the thesis entitled "**IMPACT OF LED (LIGHT EMITTING DIODE) TUBES ARTIFICIAL LIGHTING SYSTEM"ON BROILER PRODUCTION** submitted to the Department of Animal Nutrition, Genetics and Breeding, Faculty of Animal Science & Veterinary Medicine, Sher-e-Bangla Agricultural University, Dhaka-1207, as partial fulfillment for the requirements of the degree of Master of Science (MS) in Animal Nutrition, embodies the result of a piece of bona fide research work carried out by **SHEULI BALA**, Registration No.: 18-09318, Semester: **JANUARY- JUNE/2020** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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DEDICATED TO MY BELOVED PARENTS

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The Author

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LIST OF ACRONYMS & ABBREVIATION

ABBEREVIATION	FULL WORD
ADG	Average Daily Gain
ANOVA	Analysis of variance
Avg	Average
BWG	Body Weight Gain
BCR	Benefit Cost Ratio
CFL	Compact Fluorescent Light
CRI	Color Rendering Index
CSA	Canadian Standard Association
Cm^2	Square Centimeter
CP	Crude Protein
CF	Crude Fiber
DOC	Day Old Chick
DP	Dressing Percentage
DM	Dry Matter
e.g.	For example
et al	And others/Associates
FAO	Food and Agricultural Organization
FC	Feed Consumption
FCR	Feed Conversion Ratio
FI	Feed Intake
g	Gram
GFI	Global Food Intake
GIT	Gastro Intestinal Tract
i.e.	That Is
IB	Infectious Bronchitis

ABBREVIATION	FULL WORD
INCAN	Incandescent
K Cal	Kilo Calorie
Kg	Kilogram
L	Liter
LED	Light Emitting Diode
LSD	Least Significance Difference
lm	Lumens
lx	Lux Meter
ME	Metabolic Energy
Max	Maximum
Min	Minimum
nm	Nano Meter
No	Number
NS	Non –significance
ND	Newcastle Diseases
RH	Relative Humidity
SAU	Sher-e-Bangla Agricultural University
SE	Statistical Error
SD	Standard Deviation
SPSS	Statistical Package for Social Science
TI	Tonic Immobility
UV	Ultraviolet
Viz	Such as
Vs.	Versus
w	Watt
WHO	World Health Organization
Wks	Weeks

LIST OF SYMBOLES

SYMBOLES	FULL MEANING
$^{\circ}$C	Degree Celsius
$^{\circ}$F	Degree Fahrenheit
@	At the rate of
:	Ratio
<	Less than
>	Greater than
*****	5% level of significance
&	And
/	Per
±	Plus-minus
%	Percentage
β	Beta
λ	Lambda

IMPACT OF LED (LIGHT EMITTING DIODE) TUBES ARTIFICIAL LIGHTING SYSTEM ON BROILER PRODUCTION

BY

Sheuli Bala

ABSTRACT

This study was conducted to evaluate the effect of different LED light color on growth performance of broiler and compare the performance of broiler reared under two different light sources and two different light colors. A total of 120 day-old Lohmann Meat (Indian River) broiler chicks were reared for 28 days at Sher-e-Bangla Agricultural University Poultry Farm, Dhaka. Chicks were divided randomly into 3 experimental groups of 4 replicates (10 chicks with each replication). Among the three treatment groups, one group kept under Incandescent light as control (T_0) and the other groups kept under red LED light (T_1) and white LED light (T_2) were treatment groups. During the experimental periods of 4 weeks, feed intake, body weight gain, feed conversion ratio (FCR), survivability, flock uniformity values were calculated. Growth performance parameters were significantly ($P<0.05$) affected by experimental light. Birds were reared under white LED light gained superior body weights (1916.84±16.03g) compared to control (1807.36±14.50g) and red LED light (1854.38±30.93). Feed conversion ratio was comparatively better ($P>0.05$) and dressing percentage was increased ($P<0.05$) in birds reared under white LED tube light. The weight of breast, back, thigh, drumstick and giblet was significantly ($P <0.05$) high in T_2 group as compared to T_1 and control (T_0) group. In addition, the present study showed that the different color LED light in different groups had no significant effect ($P>0.05$) on relative weight of neck, wing, heart, liver, gizzard, spleen and proventiculus. Survivability was no significantly ($P>0.05$) higher in T_2 and T_0 group compared to T_1 group. However, the higher flock uniformity (76.5±7.81%) was found in T_2 group compared to T_1 (70±7.07%) and T_0 (71.95±10.97) group which was statistically insignificant ($P>0.05$). In case of cost benefit analysis, net profit was highest in T_2 group than the other groups. The study therefore concluded that, white LED tube light could be a better alternative source of light than Incandescent light in terms of growth performance of broiler chickens, economics and energy saving.

CHAPTER-1

INTRODUCTION

CHAPTER 1

INTRODUCTION

The broiler industry is one of the fastest growing industries in Bangladesh. With the rapid increase in population, the demand for animal proteins like chicken meat has increased drastically along with employment opportunities and thus helping to build up a healthy society of nation. The poultry farming contributes positively to the Bangladeshi agribusiness economy (Olanrewaju *et al*., 2006). In Bangladesh, more than half of the people depends on agriculture and livestock farming. As a result, in the last few decades' genetic selections of broiler was principally based on some criteria like rapid growth; resulting in higher weight gain and increased feed conversion ratio**.** But, the unidirectional selection of the poultry birds based on rapid growth, has resulted in the development of many undesirable traits. So, it has attracted the producers towards better management practices to remove the complications without hampering production. In this context, light management has emerged as a great tool in broiler production. It has been found that intensity, duration, color and source of light affect the production. Traits like feed consumption, feed efficiency ratio, carcass yield, disease prevention trait and different economical traits can also be controlled by proper light management. Improving broiler chicken performance through artificial lighting has been extensively studied over the past fifty years as producers have sought to increase broilers muscle gain, while maintaining an efficient feed conversion ratio and bird health (Rogers *et al*, 2015). The effect of lighting on poultry is a topic that has been studied for decades. Wavelength, intensity, photoperiod, type and placement of lighting all play an important part in bird development and performance (Olanrewaju *et al*., 2006). Several types of lighting systems, such as incandescent, fluorescent, compact fluorescent, fluorescent tube lighting and high intensity discharge lighting have all been used in commercial poultry housing. Among all light sources, light-emitted dioxide (LED) is a unique type of semiconductor diode. LEDs have a very significantly longer life of 100,000 h. In addition to their long life, LEDs have many advantages over conventional light source. These advantages include small size, specific wavelength, low thermal output, adjustable light intensity and quality, as well as high photoelectric conversion efficiencies (Alattar *et al*., 2019).

Such advantages make LEDs perfect for supporting chick growth in controlled environment. Studies in SAU Lab indicated that light period 9 and light intensity14 emitted by LEDs showed a significant influence on the growth and behavior of the chicken broilers. Further we reported that monochromatic LED light also can affect growth of the chicken broilers. Recently, light emitting diode (LED) lamps have been of growing interest in poultry operations because of their high energy efficiency (Huber-Eicher *et al*., 2013), long operating life, availability in different wavelengths (Craford, 1985) low electricity consumption and low rearing cost (Rogers *et al*., 2015). Modern lights are much more energy efficient and still provides adequate illumination. This has required new research on the entire lighting management system for growing broilers.

By selecting the optimum light source and taking advantage of the unique spectral requirements of poultry, it is possible to maximize growth and efficiency while reducing unnecessary stress and fostering ideal behavior (Archer, 2015). In the light of above mentioned facts, the present study was designed to see the impact of various lighting sources on the production performance of broilers. Artificial lighting, characterized by the type of light source, wavelength and intensity, spatial distribution of illuminance and duration of photoperiod (Mendes *et al*., 2010), acting directly on the behavior, physiology, visual comfort and welfare of the broilers. . In general, light intensity ranging from 1 to 150 lux has been found to not affect BW, feed consumption, and feed: gain ratio. (Skoglund & Palmer, 1962; Newberry *et al*., 1988; Campo & Davila 2002; Lien *et al*., 2007; Blatchford *et al*., 2009).

The broiler is a photosensitive animal, which can have its behavior and welfare affected by the illumination of the environment (Mendes *et al*., 2013). The perception of light by this species occurs by direct sensitization of the retina, a specialized region within the eyeball capable of forming images and distinguishing colors, which allows its interaction with the environment, as well as mediating the effects of light on growth and behavior. The retina of the broiler is sensitive to light of wavelength (λ), in the approximate interval of λ_{min} = 360 nm to λ_{max} = 700 nm (Wilson & lindstrom, 2011). In association, another form of light perception by broilers occurs through the photostimulation of deep regions of the brain, which cover the hypothalamus and the pineal gland (rathinman & kuenzel, 2005), through the red light with λ > 700nm, which crosses the skull (Baxter *et al*., 2014). Melatonin is a hormone synthesized by the pineal gland, retina and gastrointestinal tract, whose main function is to determine the periodicity of food intake, as well as to induce behaviors associated with the night-day cycle (Huang *et al*., 2013).

The use of light-emitting diode (LED) lamps stands out in poultry farming because it presents energy saving and provides viability of the breeding process (Santana *et al*., 2014). Other advantages attributed compared to other lamps (fluorescent and incandescent) include energy efficiency, long shelf life, resistance to humidity, availability of wide wavelengths (light intensities) (Mendes *et al*., 2013, Cao *et al*., 2012) and the low cost of dimerization in relation to fluorescent lamps. There are many benefits of choosing LED lighting for the farm. It has longest comparable lifespan. When compared to other lighting options, LEDs generally come out on top in their average rated life, luminous efficacy rating and overall energy savings. The average rated life of LEDs will vary from 15,000-100,000 hr., depending on the use and type of bulb. Most commercially available bulbs will list a rated life of 25,000-50,000 hr. When purchasing LED bulbs for use inside a barn, select bulbs rated for wet, dirty environments that come with a warranty. LEDs tend to have a very high luminous efficacy rating when compared to other lighting types. LED bulbs have an average efficacy of 85 lm/W, compared to 70 lm/W for CFL and 15 lm/W for an incandescent bulb (Watkins, 2016) .The artificial lighting used in poultry farming is mostly an adaptation of technology available to humans and there is little information on the effects of the use of poultry lamps on the productivity of the broilers (Donkon, 1989). With this background, the work was planned to explore the possibilities of LED tubes artificial lighting system on performance of broiler chicken with the following specific objectives:

1. To evaluate broiler performance and carcass yield by different LED colors compared to incandescent bulbs
2. To estimate the effect of LED light on flock uniformity of broiler chicken
3. To get maximum production and reduces electricity cost by providing LED lighting program

CHAPTER-2

REVIEW OF LETERATURE

CHAPTER 2

REVIEW OF LITERATURE

Performing any type of survey or experiment review of literature is important which are linked to the proposed study for the convenient of research work. The past research works related to the experimented has been reviewed to conduct the experiment properly. LED lighting provides an affordable lighting option for use in commercial poultry production. However, more information is needed to understand the effects of LED color on broiler welfare and growth. The effect of coloured lighting on poultry has been studied over the last 30 years and increasingly so in recent years. In the commercial market, many kinds of light have been introduced and LED lights are much more energy efficient and provide adequate illumination. Artificial illumination, including light quality is crucial in modern broiler management. In the present study, a new, highly efficient, LED lighting system has been developed for broilers. The only light source for chickens in environmental control houses is artificial. Thus, source, spectra, intensity and regimen of light supplementation become major factors in modern broiler management (Andrews & Zimmerman, 1990). A high intensity of light (64.8 lx) reduces growth rate in broilers (Barrott & Pringle, 1951). Cherry & Barwick (1962) stated that light intensities beyond 10.8 lx probably depress growth.

The literature reviewed here have been limited to these which are considered compatible and related to the objectives of the present study. Light spectra may also affect growth in broilers. The broiler producer must consider several critical factors in the design of a lighting program. Housing type is the first concern.

2.1 Importance of light in poultry physiology: Light is considered as one of the most predominant environmental factors for birds. Many physiological and behavioral processes are regulated through it and it also affects growth rate (Rault *et al*., 2017). It is important for sight both visual acuity and color discrimination. Light helps the bird to establish rhythmicity and synchronize many essential functions, including body temperature and various metabolic steps that enhance feeding and digestion. Actually, nutrient concentration, feed form and light act independently and also interactively. Light also stimulates secretory patterns of hormones that have a role in growth, maturation, and reproduction (Rozenboim *et al*., 2004). Especially, light has an impact on the pineal gland and helps in synchronization of circadian rhythm and inhibiting melatonin release (Schwean *et al*., 2016).The circadian rhythm helps the bird to optimize their metabolism, physiology and behavioral pattern.

2.2 Light parameters affecting broiler production

2.2.1 Light intensity: Manipulation of light intensity is an important management tool affecting broiler production and wellbeing. Despite considerable research on light intensity, there is still a debate on the optimum level to be used for intensively housed broilers. Body weight, feed consumption, feed: gain ratio, and mortality were unaffected by light intensity (Deaton *et al*., 1967). Carcass, thigh, and drum yield as a percentage of live weight decreased linearly with increasing light intensity. The 1 lux treatment resulted in heavier wings as a percentage of live weight. Light intensity had no effect on skeletal health, but ulcerative footpad lesions decreased linearly with increasing light intensity (Bayraktar *et al*., 2012). Birds exposed to the 1 lx treatment had heavier and larger eyes. Broiler behavior is strongly affected by light intensity. Generally, brighter light will foster increased activity, while lower intensities are effective in controlling aggressive acts that can lead to cannibalism. Producers regularly use modern electronic systems to increase light intensity for short periods during grow-out to increase exercise and thereby reduce skeletal and in metabolic disorders (Halevy *et al*., 1998). In general, light intensity ranging from 1 to 150 lx has been found to not affect BW, feed consumption, and feed:gain ratio (F:G) (Skoglund & Palmer, 1962; Newberry *et al*., 1988; Kristensen *et al*., 2006; Lien *et al*., 2007; Blatchford *et al*., 2009). Most management guides recommend a reduction in intensity after the early brooding period, but there is a debate as to the appropriate level that should be used. Our interaction with industry revealed that these recommendations are based on the perception that very low light intensities improve feed efficiency, reduce mortality due to sudden death syndrome, and reduce carcass damage (scratches, bruises) because of reduced activity. However, these advantages have not been confirmed by scientific investigation and in some cases are contrary to published data. Higher light intensity has been shown to increase bird activity and aggressive behavior (Hasan *et al*., 2013; Newberry *et al*., 1988) but a specific negative effect on broiler chicken higher light intensity within the range of 1 to 100 lx has not been scientifically demonstrated in broiler chickens.

2.2.2 Light duration: Lighting duration that is photoperiod is the second major aspect of light that alters broiler performance. Most analysis involving light-weight management has targeted on this issue. The study showed better broiler performance at continuous lighting (Benson *et al*., 2013). Lighting length is generally dependent upon the age of chickens concerned and sort of housing in use. Research and discussion continue in an attempt to define the optimal photoperiodic regime suitable for chickens. However, broilers need to be provided four hour for sleep, but they, may require higher hours at certain points of growing period. Different photoperiodic regimes have been applied and tested over the years, while almost all of them are been proved to be more beneficial for broiler production compared with conventional near-continuous lighting (Farghly *et al.*, 2019). Intermittent photoperiod significantly increases weight gain, feed-gain ratio, mobility and carcass yield with a decrease in mortality rate (Arowolo *et al*., 2019).

2.2.3 Color of light: Color is also one of the major aspects of light. There are three types of pigment in the human retina (red, green and blue) whereas chicken retina has two types (rhodopsin and iodopsin) (Yoshizawa, 1992). Daylight has a relatively even distribution of wavelengths between 400 and 700 nm. In recently advanced poultry farming management system, artificial lights are generally used, thus selection of light in the farm is crucial. Birds sense light through their eyes (retinal photoreceptors) and through photosensitive cells in the brain (extra-retinal photoreceptors). Blue and green light has a calming effect on birds, while birds reared in red light are more active and shows enhanced walking, flying, head movement, litter scratching, body shaking, wing flapping, wing/leg stretching, feather pecking, aggressiveness and cannibalism (Khaliq *et al*., 2018; Hesham *et al*., 2018). Light of different wavelengths has varying stimulatory effects on the retina and can result in behavioral changes that will affect growth and development (Lewis & Morris, 2000).

2.2.4 Constant light: When photoperiod is maintained at a constant level throughout the growth cycle of broiler chickens, shorter d length is associated with slower growth (Li *et al*., 1995). The slower growth rate is a reflection of reduced feed intake associated with shorter d and reduced leg abnormalities (Gordon, 1994). If given a choice, chickens prefer to eat during the photoperiod, although they will eat during darkness if insufficient periods of light are provided (Simmons, 1982).

2.2.5 Intermittent lighting: Research on intermittent lighting has been extensive but complicated by a wide variety of light-dark cycles and management systems. However, intermittent lighting programs have frequently resulted in superior broiler productivity in comparison to constant light (Classen, 2004a; Rahimi *et al*., 2005). In addition, intermittent lighting frequently reduces the incidence of leg disorders and has also been shown to reduce sudden death syndrome (Buckland, 1975; Simmons, 1986; Classen & Riddel, 1989). Circadian (daily) rhythms in activity and metabolism are well recognized in diurnal poultry species (Classen, 2004a).

2.3 Effect of LED light on different traits of broiler

2.3.1 Locomotory behavior: The behavior involved in walking during the light color treatment tended to increase linearly (morning F7, 72=3.39, P=0.011 and afternoon F7, 72=5.99, P=0.001) with increasing light wavelength. Expression of frequency of walking behavior both in the morning and afternoon was affected by light color in which LED tube light has significantly increased the walking behavior more than that of LED red incandescent light treatments (Lewis & Hurnik, 1990).

2.3.2 Feeding behavior: In the commercial market, many kinds of light have been introduced and LED lights are much more energy efficient and provide adequate illumination. The feeding behavior was not influenced by the light color in the morning but was influenced (F7, 72=3.00, P=0.032) in the afternoon. In the present results, LED tube light color did stimulate the feeding behavior of broiler. On the other hand, drinking behavior was not significantly affected by the light color (Newberry & Blair, 1993).

2.3.3 Foraging and comfort behavior: The present result also showed that the ground pecking (GP), wing flapping (WF) and wing stretching (WS) were not significantly responsive to the light color. Within the time budget, this behavior was not influenced either in the morning or in the afternoon but higher frequency was obtained under the Red lighting treatment and lower under the white lighting (Alvino *et al*., 2009).

2.3.4 Fear responses of broiler: Although the fear response is difficult to assess, Jones and Faure (1981) have developed a test known as tonic immobility which has widely used to study fear responses of birds (Jones & Mills, 1983; Mills & Faure, 1986). In addition, Campo and Carnicer (1994) have quantified tonic immobility by associating high levels of corticosteroid production with an increase in tonic immobility times. In the first treatment, birds reared under incandescent light showed longer tonic mobility than other treatment. In the second treatment, birds reared under LED red light and showed lower tonic immobility than first treatment group. And finally in the third treatment group under white LED tube light birds showed significantly lower tonic immobility than other treatment groups. Due to the lack of previous studies regarding the effect of light color on fear response of broiler productivity, a direct comparison was not possible. But we predict that broilers spend more active time under long wavelength than under short wavelength light and this might influence the duration of tonic immobility (Manser, 1996).

2.3.5 Growth performance of broiler: The only light source for chickens in environmental control houses is artificial. Thus, source, spectra, intensity, and regimen of light supplementation become major factors in modern broiler management (Andrews & Zimmerman, 1990). A high intensity of light (64.8 lux) reduces growth rate in broilers (Barrott & Pringle, 1951). Cherry & Barwick (1962) stated that light intensities beyond 10.8 lx probably depress growth. Light spectra may also affect growth in broilers. Broilers raised under blue (BL) or green fluorescent lamps (GL) gained significantly more weight than birds reared under red (RL) or white light (WL), whereas feed conversion and mortality were not affected (Wabeck & Skoglund, 1974). One of the biggest challenges in broiler production is related to power consumption, which substantially increases production cost (Yanagi junior *et al*., 2011; Pereira *et al*., 2012). Thus, the ideal light program provides maximum production and reduces energy expenses. Light spectrum refers to the amalgamation of different powered wavelengths of electromagnetic radiation emitted from a light source, and for this paper is limited to the range visible to poultry from 350 to 700 nm. The visual range of poultry differs from that of a human in several ways, the most striking being inclusion of the ultraviolet (UV) range due to the addition of a fourth type of single-cone photoreceptor (Osorio *et al*., 2004; Prescott & Wathes, 1999). Spectral sensitivity is not even across the spectrum, and birds have been shown to have maximum visual sensitivity at 415 nm, 455 nm, 508 nm, and 571 nm (Prescott *et al*., 2003).

Since there has been limited research on the behavioral and physical effects of modern light sources on poultry, an experiment was conducted to elucidate any differences between 3 types of light source. The objective of this study was to evaluate how 2 brands of LED bulbs and an alternative CFL blub that are available to the poultry industry, each of which produces a different spectral output, affect production and welfare of broiler chickens (Kristensen *et al*., 2007). It also compared several stress, fear, and welfare assessments to best determine how changes in lighting affect bird behavior, performance, and efficiency. It is hypothesized that the use of LEDs in place of CFLs will not result in any negative effects on behavior or production, and will act to reduce stress and fear responses in growing and adult birds.

Paixao *et al*., (2011) studied two light sources (fluorescent and white LED) and observed no difference in broiler performance. Cao *et al*., (2008) evaluated four LED colors (white, red, blue and green) in poultry production and found different results. Those results indicated that birds kept under blue light showed higher body weight at 21-48 day growth. Rozenboim *et al*., (2004) also found higher body weight in broilers exposed to blue and green light at 34 day growth, but found no difference in feed conversion throughout total rearing period.

2.4 Comparison of LED light bulbs to incandescent bulbs and their effects on broiler chicken

For many years the industry has relied on incandescent light bulbs to provide illumination in poultry houses. These bulbs come in a variety of colors and intensities, but are currently being phased out due to their relatively high power consumption (Archer, 2015). Fluorescent lights, especially the newer compact fluorescent lights (CFLs), offer a significantly lower level of power consumption for a similar light output and are currently favored by the industry (Buyse *et al*., 1996). However, CFLs do not all work well on the dimmers needed to set an adequate light level in the house and those that do, have not standardized their function. They also contain small levels of toxic heavy metals that may cause problems if the bulb is broken. More recently light emitting diodes (LEDs) have been moving into the market and are becoming more affordable (Nissa *et al*., 2018). They offer much longer life spans than the other types of bulbs, decrease power consumption and provide a different spectrum output which has been described as more realistic by various reviewers (Xie *et al*., 2008). By selecting the optimum light source for a particular flock, one should be able to maximize growth and efficiency while reducing unneeded stress and fostering ideal behavior.

Since there has been limited research on the behavioral and physical effects of modern light sources on poultry, an experiment was conducted to elucidate any differences between 3 types of light source. The objective of this study was to evaluate how 2 brands of LED bulbs and an alternative CFL blub that are available to the poultry industry, each of which produces a different spectral output, affect production and welfare of broiler chickens (Deep *et al*., 2010). It also compared several stress, fear, and welfare assessments to best determine how changes in lighting affect bird behavior, performance, and efficiency. It is hypothesized that the use of LEDs in place of CFLs will not result in any negative effects on behavior or production, and will act to reduce stress and fear responses in growing and adult bird (Fernandes *et al*., 2018).The eventual removal of incandescent lights from the market has left poultry producers with the need to find alternative lighting sources. Light-emitting diode (LED) and compact fluorescent lamp (CFL) bulbs have arisen as the likely replacements for incandescent lights (Siopes *et al*., 2018). However, there is little knowledge how these bulbs compare with each other in how they affect bird production, behavior and stress. To investigate this broilers (n = 120 per treatment) were raised under incandescent (INCAN), CFL, or LED lighting or an alternative of using LED lights at bird level (Archer, 2016). All lighting was 23L:1D at 20 lx for 14 d and then was changed to 20L:4D at 5 lux for the remaining 31 d. Fearfulness was determined using several fear tests and stress susceptibility was assessed using a composite asymmetry score determined by middle toe length and metatarsal length and width (Prayitno *et al*., 1997). All alternative lighting to INCAN improved weight gain at 45 d ($p<0.05$). Both LED treatments exhibited less fear and less stress susceptibility than those raised under CFL or INCAN ($p<0.05$). Using CFL and LED bulbs can increase the size of the birds while not changing FCR and LED bulbs appear to reduce fear and stress in older birds compare with CFL and INCAN bulbs (Archer, 2016). The result also indicate that LED tube light not only increases growth and feed conversion but result in birds that are less fearful and less stress susceptible. This method of illuminating birds might save energy and improve production and bird welfare.

CHAPTER-3

MATERIALS & METHODS

CHAPTER 3

MATERIALS AND METHODS

3.1 Statement of the experiment

To check the impact of LED tube artificial lighting system on production performance as well as growth of broilers, the present study was conducted at SAU Poultry Farm, Faculty of Animal Science and Veterinary Medicine, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period of 3rd November to 1st December, 2019

3.2 Collection of experimental broilers

A total of 120 day old chicks of "Lohman" strain weighing 44.2±0.5g average body weight were obtained from Kazi hatchery distribution point, Savar, Dhaka.

3.3 Experimental design

One hundred and twenty day old broiler chicks were obtained from a Kazi hatchery. After one week the chicks were weighed by using an electronic balance and the chicks having similar body weights were distributed randomly into three light treatment groups viz, Incandescent (T_0) as control, red LED light (T_1) and white LED tube light (T_2) having 40 chicks in each which were again subdivided into four replicates randomly of 10 chicks each. Each treatment group was housed in a light proof enclosure. Continuous lighting was provided to the birds similar intensity in all treatment groups was maintained. The light intensity was kept similar in all the treatment groups and monitored regularly using a digital lux meter. The experimental barn was cleaned thoroughly and kept under similar housing and management conditions like floor space, temperature, ventilation, humidity, *ad-libitum* feed and fresh water except sources of light. Performance parameters in terms of measurement of weekly body weight, body weight gain, weekly feed consumption, feed conversion ratio (FCR), mortality and leg weakness was recorded. The experiment was carried for a period of four weeks.

3.4 Experimental materials

The chicks were collected from Kazi hatchery and carried to the university poultry farm early in the morning. Then the chickens were kept in the electric brooders for 7 days by maintaining standard brooding protocol. During brooding time only basal diet was given. After successful brooding the chicks were distributed randomly in three (3) treatment. Each treatment had four (4) replications with 10 birds per replication. The total number of treatments were three (3) and their replications were twelve (12). Each pen was provided with feeder and drinker. Feed and water were offered *ad libitum*. After 28 days of, data were collected for the following parameters: feed intake, live weight, body weight gain, feed conversion ratio, profit per bird and benefit-cost ratio.

3.5 Experimental treatments

- T_0= 40W incandescent light
- T_1= Red LED light
- T_2= White LED tube light

Table 1: Layout of the experiment

Treatment Group	Number of Replication				Total
	R_1	**R_2**	**R_3**	**R_4**	
T_0	10	10	10	10	40
T_1	10	10	10	10	40
T_2	10	10	10	10	40
Total	30	30	30	30	120

3.6 Preparation of broiler house: The broiler shed was an open sided natural house. Cross ventilation system was provided by using wire-net. It was a tin shed house with concrete floor. There was 1ft. side wall around the shed with no ceiling. The floor was above 1ft. from the ground and the top of the roof was above 15 ft. from the floor. Polythene sheet was hanged around the side wall to protect the chicks from cold, storm, dusts and heavy rainfall.

The house was properly cleaned, rubbed with bleaching powder and washed the floor by using tap water and then disinfected by diluted iosan solution before starting the experiment. After proper drying of floor, equal size (1 m × 1 m) wire net floor pens were made as per layout of the experiment. The height of the pens was 0.5m. Before placement of chicks the house was fumigated by formalin and potassium permanganate @ 500 ml formalin and 250 g potassium permanganate (i.e. 2:1) for 35 m3 experimental area. One feeder and one waterer were distributed each pen. The stocking density was 1 m^2/10 birds.

3.7 Experimental diets

Starter and grower commercial Kazi broiler feed were purchased from the market. The experimental birds were fed *ad libitum*. The experimental rations consisted of broiler starter and broiler finisher. Broiler starter feed were used day 1 to day 14 and broiler grower feed was used day 15 to day 28. Purchased feed bag open only feeding time and rest part of day bag was tightly closed with a rope. After complete using of one bag, another bag is open for feeding. Nutritional value of purchased feed as shown below-

Table 2: Name and minimum percentage of nutrients present in starter broiler ration

Name of nutrients	Amount (%)
Protein	21.0
Fat	6.0
Fiber	5.0
Ash	8.0
Lysine	1.20
Methionine	0.49
Cysteine	0.40
Tryptophan	0.19
Threonine	0.79
Arginine	1.26 %

Table 3: Name and minimum percentage of nutrients present in grower broiler ration

Name of nutrients	Amount (%)
Protein	19.0
Fat	6.0
Fiber	5.0
Ash	8.0
Lysine	1.10
Methionine	0.47
Cysteine	0.39
Tryptophan	0.18
Threonine	0.75
Arginine	1.18

Feed were supplied 4 times daily by following Lohmann manual. *Ad libitum* drinking water were supplied two times daily.

3.8 Source of light

There are different kinds of lamps available to poultry producers: incandescent, fluorescent, metal halide, CFL (compact fluorescent) and LED (light emitting diode). All are in use in poultry facilities for laying hens, breeder flocks, broilers, and turkeys. Average feed intake was significantly higher in white LED tube light and compared to Incandescent and red LED light (Cao *et al*., 2008). Similarly, the feed conversion ratio (FCR) was significantly higher in white LED tube and Incandescent groups compared to red LED light. So, it can be said that modern light sources like LED can be used in place of INCAN for more profit.

3.9 Management of LED

Lighting is a powerful exogenous factor in control of many physiological and behavioral processes. Light may be the most critical of all environmental factors to birds. The broiler producer must consider several critical factors in the design of a lighting program. Color LED bulb was used for lighting. 24 hour lighting per day was provided throughout the experimental period. During early stage of age, the bulbs were hanged just above the chick's level at the center of pen. In the course of the trial, the temperature was gradually reduced up to the end of trial. For optimum ventilation the curtain management was done properly. The farm was divided in 3 treatment groups. Each treatment group is used for different color light. 5 blubs are used in Control group (T_0) and Treatment -1 group for lighting and 3 LED tube light is used in Treatment-3 group.

Fig 1: Different lights that were used in different treatment groups

3.10 Management procedures

Chicks were weighed individually at the beginning of experiment and at weekly intervals in all the groups using a digital weighing balance before offering feed to the birds. Body weight and feed intake were recorded every week and survivability was recorded for each replication up to 28 days of age. The following management procedures were followed during the whole experimental period.

3.10.1 Litter management

Managing litter quality is an important aspect of raising healthy broilers economically. Litter quality both directly and indirectly impacts bird respiratory health, microbe numbers and viability, ventilation needs, power usage and worker health. For these reasons, managing broiler litter should be an organized effort by broiler rearing personnel. Bedding material that was high absorbing was used as litter on floor. Clean, fresh and sundried rice husk was used as shallow litter to absorb moisture from fecal discharge of broiler chicken. The shallow litter was 6cm in depth. About 200g calcium powder was mixed with rice husk in every pen as disinfectant. At the end of each week the litter was harrowed to prevent accumulation of toxic gases and to reduce moisture and parasitic infestation. At 3rd and 4th week of rearing period, dropping was cleaned from the surface level by removing a thin layer of litter and same amount new litter was placed in each pen.

3.10.2 Care of day-old chicks

Just after arrival of day-old chicks to the poultry house the initial weight of the chicks were recorded by a digital electronic balance and distributed them under the hover for brooding. The chicks were supplied glucose water with vitamin C to drink for the first 6 hours to overcome dehydration and transport stress. Subsequently small feed particles were supplied on the newspapers to start feeding for the first 24 hours.

3.10.3 Brooding of baby chicks

The experiment was conducted during 3rd November to 1st December, 2019. The average temperature was 28.07ºC and the relative humidity was 68% in the poultry house. Electric lamp brooder was used to brood the chicks. Partitioning was done due to different experimental treatment. Each brooder had one hover and a round chick guard to protect chicks and four partitioning chambers. The brooding was adjusted on the behavior and comfortable of the chicks. Thereafter, healthy baby chicks were randomly distributed to the pen according to the design of the experiment. Common brooding was performed for first week (maintain 32.2^{o}C temperature). After one week brooding the chicks were distributed in the pen randomly. There were 10 chicks in each pen and the pen space was 1m^2. Brooding temperature was maintained as per requirement. Brooding temperature was adjusted (below 35ºC) with house temperature by using heat producing electric bulb. Moreover, at that time the wall polythene sheet spread over the net-wire to protect the chicks from cold and wind.

3.10.4 Room temperature and relative humidity

Daily room temperature (°C) and humidity were recorded with a thermometer and a wet and dry bulb thermometer, respectively. Average room temperature and percent relative humidity for the experimental period were recorded and is presented in Table 4.

Table 4: Recorded temperature and relative humidity (%) during experimental period

Age in weeks	Period	Average Tem. (ºC)	Average Humidity (%)
1st	03.11.19-10.11.19	32.2	64.3
2nd	11.11.19-17.11.19	28.0	69.0
3rd	18.11.19-24.11.19	25.5	66.2
4th	25.11.19-01.12.19	25.9	69.0

3.10.5 Feed and Water supply

Providing the right nutrition is important for poultry growth, production and health. Different energy requirements are required, depending on factors including bird age and production status. Feed and fresh clean water were offered to the birds *ad libitum.* One feeder and one round drinker were provided in each pen for 10 birds. At the end of each week feeder were cleaned and drinkers were washed daily morning. All mash dry feed was feed to all birds *ad libitum* during the experimental period.

3.10.6 Ventilation

The broiler shed was south facing and open sided. Due to wire net cross ventilation it was easy to remove polluted gases from the farm. Besides, on the basis of necessity ventilation was regulated by folding polythene screen.

3.10.7 Biosecurity measures

Biosecurity is the product of all actions undertaken by an entity to prevent introduction of disease agents into a specific area. To keep disease away from the broiler, farm the following vaccination, medication and sanitation program was undertaken.

3.10.8 Vaccination

Vaccines were collected from medicine shop (HIPRA Company) and applied to the birds according to the schedule. The vaccination schedule is given in Table 5.

Table 5: Vaccination schedule

Age of Birds	Name of Disease	Name of Vaccine	Route of Administration
3 days	IB+ND	HIPRAVIAR B1/H120	One drop in each eye
9 days	Gumboro	HIPRAGUMBORO GM97	Drinking Water
17 days	Gumboro	HIPRAGUMBORO GM97 (booster)	Drinking water

3.10.9 Sanitation

Good hygiene standards reduce disease challenge. Farm sanitation does not just mean the choice of the right disinfectant. The key to farm sanitation is effective cleaning. Throughout the experimental period proper hygienic measures were maintained. During the experimental period strict sanitary measures were taken. Disinfectant (Timsen) was used to disinfect the feeders, waterers and house also. There was a provision of foot bath at the entry gate of the broiler shed to prevent any probable contamination of disease. Farm dress, shoes and hand gloves were used during the experimental period.

3.10.10 Medication

Broiler medication program is an important to keep disease free flock in commercial broiler farming. This process includes receiving day-old chick (DOC) and medication program in different days of bird's age. Vitamin-B complex, Vitamin-A, D3, E were used against deficiency diseases. Electrolyte and vitamin-C also used to save the birds from heat stress.

3.11 Recorded parameters

Weekly lives weight, weekly feed consumption and death of chicks to calculate mortality percent. FCR was calculated from final live weight and total feed consumption per bird in each replication.

3.12 Data collection

The experiment was carried out by collecting data from the five treatment. Feed intake (FI), body weight gain (BWG), feed conversion ratio (FCR), profit per bird, mortality percentage, uniformity, benefit cost ratio of different experimental birds were calculated. Detail of each data collection procedure are given below:

3.12.1 Live weight

The initial day-old live weight and weekly live weight of each replication was kept to get final live weight record per bird.

3.12.2 Feed consumption

Daily feed consumption record of each replication was kept to get weekly and total feed consumption record per bird.

3.12.3 Mortality of chicks

Daily death record for each replication was counted up to 28 days of age to calculate mortality.

3.12.4 Dressing yield

Live weight – (blood + feathers + shank + head + liver + heart + digestive system)

3.12.5 Flock uniformity

Uniformity is a measure of the variability of bird size in a flock. To determine the average weight and uniformity of flock, divided the house into three sections. One hundred and twenty birds were weighed individually to determine flock. It is important to weigh all birds within the each pen, excluding culls.

$$\text{Flock uniformity} = \frac{\text{Average weight} - \text{Total birds (Average weight of birds} \pm 10\%)}{\text{Average weight}} \times 100$$

Here, Average weight of birds = Birds weight/Total birds

3.13 Dressing procedures of broiler chicken

Three birds were picked up at random from each replicate at the 28th day of age and sacrificed to estimate dressing percent of broiler chicken. All birds to be slaughtered were weighed and fasted by halal method or overnight (12 hours) but drinking water was provided *ad libitum* during fasting to facilitate proper bleeding. All the live birds were weighed again prior to slaughter. Birds were slaughtered by severing jugular vein, carotid artery and the trachea by a single incision with a sharp knife and allowed to complete bleed out at least for 2 minutes. Outer skin was removed by sharp scissor and hand. Then the carcasses were washed manually to remove loose singed feathers and other foreign materials from the surface of the carcass. Afterward the carcasses were eviscerated and dissected according to the methods by (Jones *et al*., 1982). Heart and liver were removed from the remaining viscera by cutting them loose and then the gallbladder was removed from the liver. Cutting it loose in front of the proventiculus and then cutting with both incoming and outgoing tracts removed the gizzard. Giblet were collected after removing the gall bladder. All the carcasses were washed with cold water inside and out to remove traces blood, loosely attached tissue or any foreign materials. Then the eviscerated weight of carcasses was recorded. Thereafter the weight of carcass cuts such as breast, thigh (both), drumstick (both), back, neck, wing (both), heart, liver and gizzard was taken. Dressing yield was found by subtracting blood, feathers, head, shank, liver, heart and digestive system from live weight. Liver, heart, gizzard and neck were considered as giblet. Percent of breast, thigh, drumstick, back, wing, giblet and abdominal fat were found as DP by the following formula-

$$\text{DP} = \frac{\text{Dressing yield (g)}}{\text{Live weight (g)}} \times 100$$

3.14 Calculations

3.14.1 Live weight gain

The average body weight gain of each replication was calculated by deducting initial body weight from the final body weights of the birds.

Body weight gain = Final weight – Initial weight

3.14.2 Feed intake

Feed intake was calculated dividing the total feed consumption in replication by number of birds in each replication.

$$\text{Feed intake (g/bird)} = \frac{\text{Feed intake in a replication}}{\text{No. of birds in a replication}}$$

3.14.3 Feed conversion ratio

Feed conversion ratio (FCR) was calculated as the total feed consumption divided by weight gain in each replication.

$$FCR = \frac{\text{Feed intake (kg)}}{\text{Weight gain (kg)}}$$

3.15 Economic analysis

3.15.1 Cost record

The production cost was calculated involved in chicks, feed, vaccine and medication. Feed cost was calculated by the average amount of feed consumed in each treatment on phase basis. Litter cost was calculated with the required amount of rice husk bags multiplying rice divided by number of birds in each replication. Cost of Incandescent bulb, red LED and white LED tube light were also calculated. All expenses and income were calculated on the basis of market price at the time of experimental period.

3.15.2 Benefit cost ratio (BCR)

The capital expenditure, recurring expenditure and depreciation cost were considered to calculate total expenditure. The major expenditure included cost of chick, feed, litter, medicine, vaccine and labor and electricity charges. Net profit was found out by deducing the total expenditure from the total income according to replication under each treatment.

$$BCR = \frac{\text{Total Income}}{\text{Total cost of production}}$$

3.16 Statistical analysis

Total data were complied, tabulated and analyzed in accordance with the objectives of the study. Excel Program was practiced for preliminary data calculation. The collected data was subjected to statistical analysis by applying one-way ANOVA using Statistical Package for Social Sciences (SPSS version 25.0) in accordance with the principles of completely randomized design (CRD). Differences between means were tested using Duncan’s multiple comparison test, and significance was set at $P<0.05$.

Some Pictorial View of the Experiment



Plate 1: Cleaning of farm and floor washing with detergent



Plate 2: Cleaning feeder and drinker and preparing bedding material

Plate 3: Chick receiving and vaccination program

Plate 4: Distribution of chicks in each replication

Palate 5: Measuring lux of different color of LED light with lux meter

Plate 6: Preparation and distribution of feed

Plate 7: Supervisor observation, weighing bird and final data collection

Plate 8: Vaccine and Medicine that are used during experimental period

CHAPTER-4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Production performance of broiler by using LED light

Providing different color of LED light to broiler improves growth performance in terms of feed consumption, body weight gain and feed conversion ratio (FCR). The chicks were randomly divided into three experimental treatment groups. The five groups were T_0 (Incandescent bulb) as control, T_1 (Red LED light), and T_2 (White LED tube light). The performance traits viz. final live weight, body weight gain, feed consumption, FCR, survivability and flock uniformity.

The analysis of research data is given and discussed below:

4.1.1 Final live weight

The final live weight data is presented in table-6.The average live weights at 4 weeks of age was recorded as 1807.37±14.50, 1854.38±30.93, and 1916.84± 16.03g, respectively for birds reared under Incandescent, Red LED, and white LED tube light groups. There were significant ($P<0.05$) differences found in the mean body weight and body weight gain of birds among the different treatment groups. The highest result was found in T_2 (1916g±16.03) and lowest result was in T_0 (1808.37g±14.50) control. Results also demonstrated that the live weights also varied among the treatment groups having statistical significance ($P<0.05$).

The results of the present study is not supported by the findings of (Hunt *et al*., 2009), (Schwean *et al*., 2010), (Lewis & Morris, 2000), (Riddell *et al*., 1992) and (Khaliq *et al*., 2018) who reported that light sources has no significant effect on live weight. (Olanrewaju *et al*., 2011) also found no difference among Incandescent, CFL and Neutral-LED light bulbs on body weight of broilers.

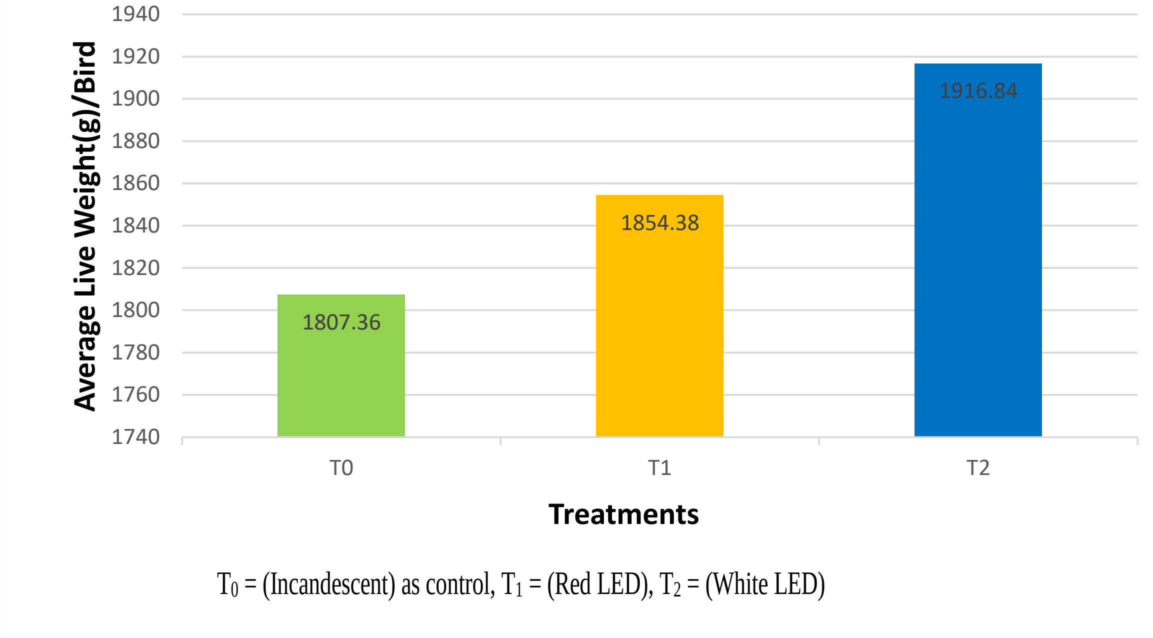

Fig 2: Average live weight (g/bird)

Table 6: Production performance of broiler chicken with different treatments

Treatment	Av. Live weight±SE	Av. Feed consumption±SE	Av. BWG±SE	FCR±SE	Survivability±SE
T_0	1807.36^c±14.50	2386.85±13.86	1764.37^c±15.48	1.35±0.00	97.5±2.50
T_1	1854.38^b±30.93	2425.61±34.51	1810.38^b±30.93	1.34±0.01	100±0.00
T_2	1916.84^a±16.03	2478.81±51.80	1872.84^a±16.03	1.32±0.02	97.5±2.50
Mean±SE	1859.52±17.67	2430.42±22.33	1815.85±17.65	1.33±0.01	98.33±1.12

Here, T_0 = (Incandescent) as control, T_1 = (Red LED), T_2 = (White LED); Values: Mean ± SE; Applying: One-way ANOVA (SPSS, Duncan method)

- Mean with different superscripts are significantly different ($P<0.05$)
- Mean within same superscripts don't differ ($P>0.05$) significantly
- SE= Standard Error

4.1.2 Weekly body weight gains (WBWG)

The data of weekly body weight gains of broiler chicks presented in (Table 7 & Figure 3).The mean body weight gains (g) at the 1st, 2nd and 3rd week of different treatment groups were not significant. The mean body weight gains (g) of broiler chicks at 4th week in different groups were T0 (704.00±13.14), T_1 (753.50±17.91), T_2 (772.75±8.18), respectively. At the 4th week the highest result was found in T_3 (772.75g±8.18) and lowest result was in T_0 (704.00g±13.14) control group and that was statistically significant (P<0.05).

These results are in agreement with those of previous researchers (Borille *et al*., 2013) who recorded non-significant (P>0.05) effects of LED light on body weight gain of different weeks. Feed intake and weight gain was not significantly influenced by light sources or periods. This indicated that birds had the same visual sensitivity to all tested light sources, and did not change their feeding behavior as a function of light source. Paixao *et al*., (2011) verified that the white LED lamp has the same effect of the fluorescent lamp on the productive performance of broilers like feed intake, live weight, feed conversion ratio (FCR), making it viable due to the saving of electric energy. For (Edwards & Torcellini, 2002) LED illumination in different colors and illuminance, when compared to fluorescent light, did not affect growth performance parameters of broilers like weight gain, feed intake and feed conversion ratio (FCR).

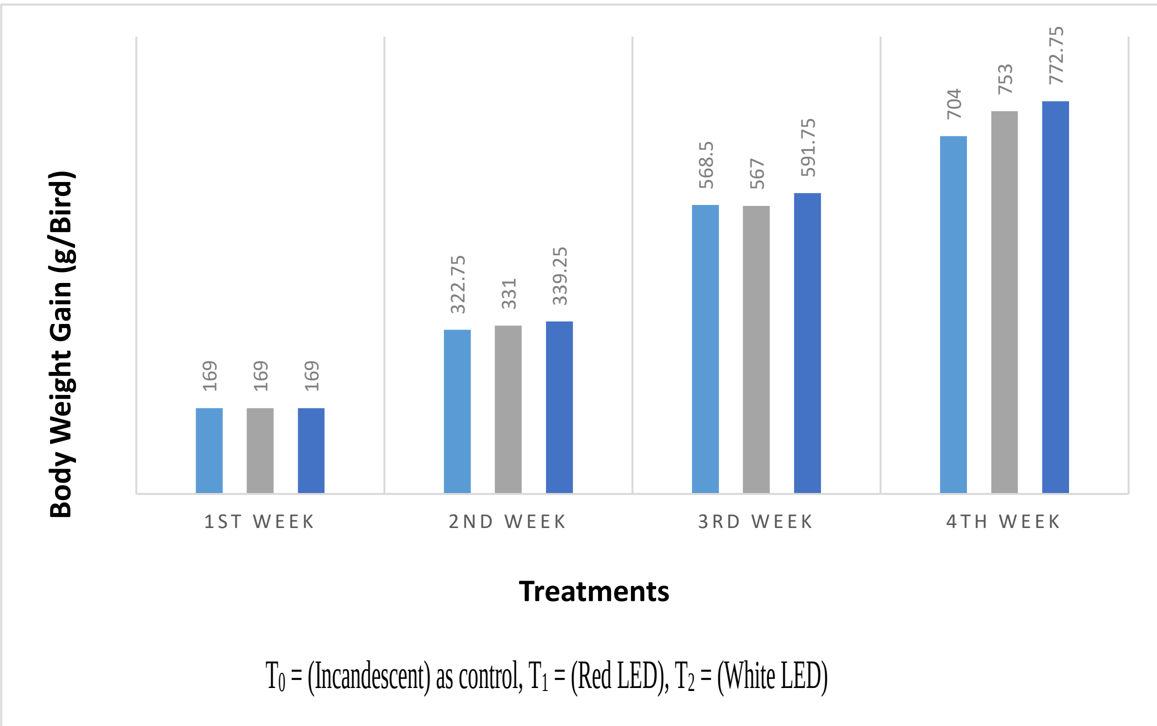

Fig 3: Effect of various color LED light on weekly body weight gain (g/bird)

Table 7: Effects of different color LED light on body weight gain (BWG) (g/bird) of broiler chicken at different weeks

Treatment	1st Week±SE	2nd Week±SE	3rd Week±SE	4th Week±SE	Total BWG±SE
T_0	169.00±0.00	322.75±5.00	568.50±9.43	704.00^{c}±13.14	1764.25^{c}±15.45
T_1	169.00±0.00	321.00±5.30	567.00±17.40	753.50^{b}±17.91	1810.50^{b}±30.82
T_2	169.00±0.00	339.25±13.11	591.75±11.57	772.75^{a}±8.18	1872.75^{a}±16.03
Mean SE	169.00±0.00	327.67±5.16	575.75±7.71	743.42±11.27	1815.83±17.63

Here, T_0 = (Incandescent) as control, T_1 (Red LED), T_2 = (White LED); Values: Mean ± SE; Applying: One-way ANOVA (SPSS, Duncan method)

- Mean with different superscripts are significantly different ($P<0.05$)
- Mean within same superscripts don't differ ($P>0.05$) significantly
- SE= Standard Error

4.1.3 Total feed consumption (FC)

Total feed consumption of different treated groups and control group have been presented in Table 8. The average feed consumption of T_0, T_1 and T_2 are 2386.85g±13.86, 2425.61g±34.51 and 2478.81g±51.80 respectively. Result in total feed consumption demonstrated that treatment groups showed significant ($P<0.05$)

These results are in agreement with those of previous researcher (Ashton *et al*., 1973) reported that feed consumption was maximum for hens subjected to white LED light. The birds under white light were found to be active and therefore the energy expenditure was more which could be the possible reason for higher feed intake. The results of the present study are also in agreement with (Charles *et al*., 1992; Berk, 1995) who found significant effect of light source on feed consumption of broiler.

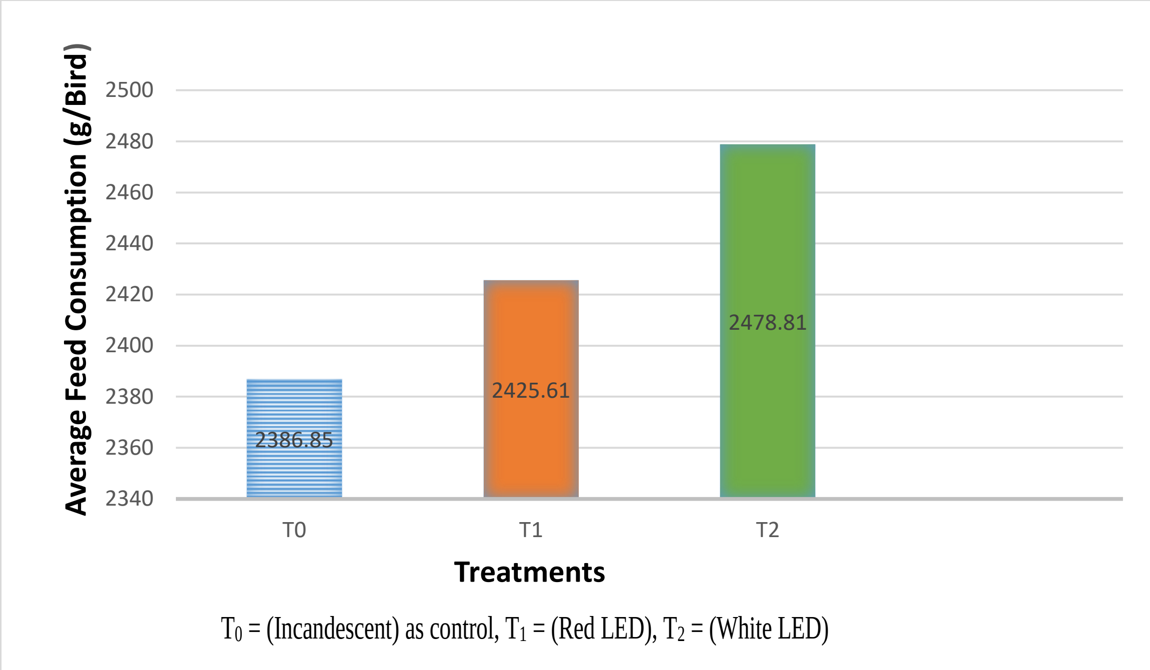

Fig 4: Average feed consumption (g/bird)

4.1.4 Weekly feed consumption (FC)

Data presented in fig 5 and table 8 showed that the mean feed consumption (g) of broiler chicks at the end of 1st week in T_0, T_1, T_2, groups were 191.70±0.00, because the 1st week was common brooding period.

The mean feed consumption (g) of broiler chicks at the end of 2nd week in different groups were 414.28±3.81 (T_0), 418.93±1.78 (T_1), and 431.90±10.55 (T_2) respectively. The overall mean feed consumption of different groups showed that there was no significant ($P>0.05$) effects. The higher feed consumption was in T_2 group and lowest in T_0 group.

Feed consumption (g) of broiler chicks at the end of 3rd week in different groups were 744.61±9.94 (T_0), 765.38±15.30 (T_1) and 779.11±15.26 (T_2) respectively.

At the end of 4th week, the feed consumption of broiler chickens are 1031.33±3.35 (T0), 1050.37±21.61 (T_1) and 1071.33±27.58 (T_2) respectively.

Sultana *et al*. (2013) also found that blue/green light caused birds to rest more than yellow/red light. The incandescent lamp emits long wavelength light (towards yellow to red end of spectrum) therefore more long wavelength light would have reached the hypothalamus making the birds more active hence increasing the feed consumption and it has also been stated by (Jin *et al*., 2010) that feed consumption was maximum for hens subjected to red light.

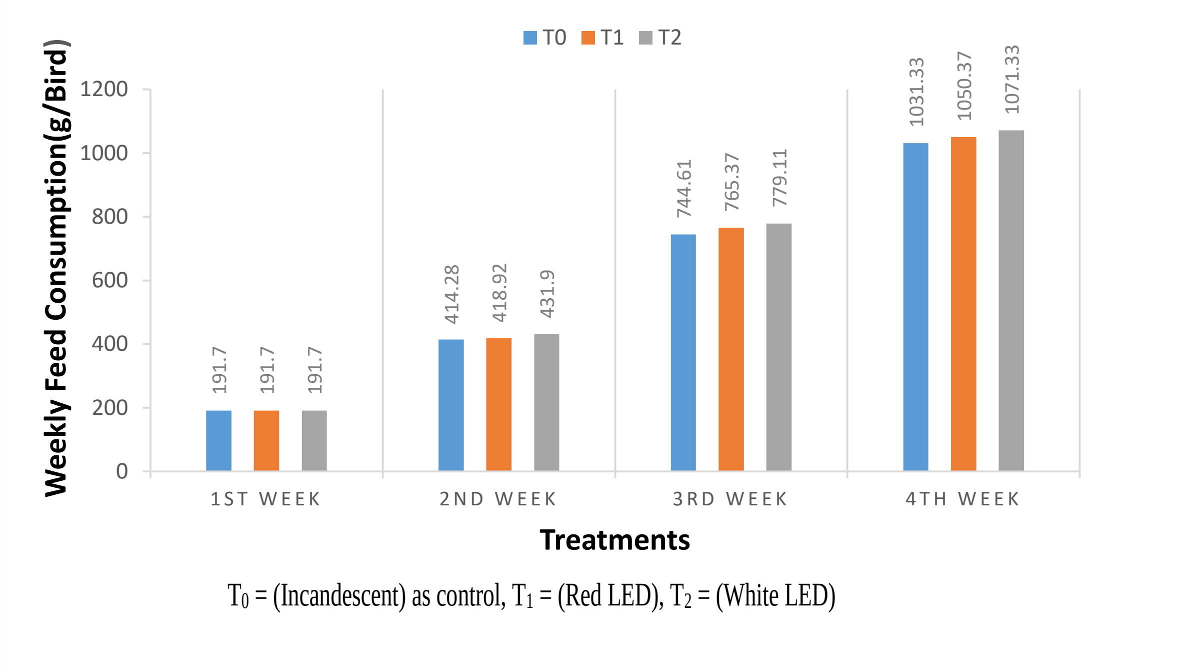

Fig 5: Feed consumption (FC) of broiler at different weeks

Table 8: Effects of different color LED light on the feed consumption (g/bird) of broiler chicks at different weeks

Treatment	1st Week±SE	2nd Week±SE	3rd Week±SE	4th Week±SE	Total FC±SE
T_0	191.70±0.00	414.28±3.81	744.61±9.94	1031.33±3.35	2386.85±13.86
T_1	191.70±0.00	418.92±1.78	765.37±15.30	1050.37±21.61	2425.61±34.51
T_2	191.70±0.00	431.90±10.55	779.11±15.26	1071.33±27.58	2478.81±51.80
Mean±SE	191.70±0.00	421.70±4.09	763.03±8.35	1051.01±11.70	2430.42±22.33

Here, T_0 = (Incandescent), T_1 = (Red LED), T_2 = (White LED); Values: Mean ± SE; Applying: One-way ANOVA (SPSS, Duncan method)

- Mean with different superscripts are significantly different ($P<0.05$)
- Mean within same superscripts don't differ ($P>0.05$) significantly
- SE= Standard Error

4.1.5 Feed conversion ratio (FCR)

The result of feed conversion ratio (FCR) of broilers under different treatment groups have been shown in Figure 6. The feed conversion ratio (FCR) was relatively higher in T_0 group (1.35±0.02) and T_1 group (1.34±0.02) compared to T_2 (1.32±0.03). The FCR of different groups showed that there was no significant ($P>0.05$) increase in groups T_1 and T_2 compared to control. However, feed conversion ratio (FCR) was found comparatively better in T_2 (1.32±0.03) group compared to T_1 and T_0 group.

This study agrees with Mendes *et al*. (2013). This does not agree with Huth &Archer (2015) previous report who observed an increase in feed conversion in two different LED bulbs over CFL bulbs. This difference could be explained by the fact that the LED used in this study was not one of the bulbs used in Huth & Archer (2015); furthermore, it was demonstrated in (Khan & Abas, 2011) that not all LED bulbs produce the same light and that effects birds differently as a consequence.

Rogers *et al*. (2015) also observed an increase in growth in broilers raised under LED or CFL when compared to INCAN. Though again this is not always constant observation with LED bulbs as Olanrewaju *et al*. (2015) observed increased weight gain in one type of LED bulb over INCAN bulbs but did not see the same effect in another LED bulb. The LED bird treatment had better feed conversion than the INCAN birds as well and as this was a novel approach to lighting broilers it is an interesting finding. The increased feed conversion could be due to birds being attracted to the feed and water sources to more efficiently eat and also could be related least amount of fear and stress susceptibility and also had the best feed conversion (Lien *et al*., 2007).

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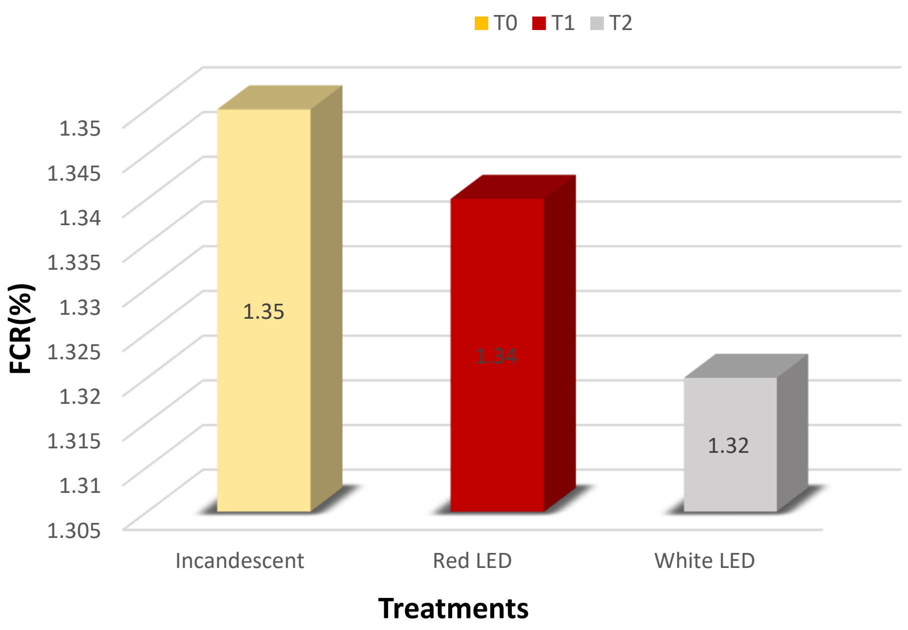


T_0 = (Incandescent) as control, T_1 = (Red LED), T_2 = (White LED)

Fig 6: Feed conversion ratio (FCR)

4.1.6 Survivability

Survivability rate of broiler chickens treated with different color LED light presented in and figure 7. The result denoted that the survivability rate of the broilers in the treatment 1 (T1) group (100±00) was higher than control group (97.5±3.33) and Treatment 2 (T2) groups (97.5±3.33) but did not differ significantly (P>0.05).

The results are in good agreement with the findings of (Maddocks *et al*., 2001); (Raccoursier, 2016); (Purcell *et al*., 2018); (Mobarkey *et al*., 2010); (Riber, 2015); (Onbasilar *et al*., 2007) and (Liu & Settar, 2018) who found no effect of light source on the mortality of broiler birds. Ferrante *et al*. (2006) also found no significant difference on mortality of broilers when reared under incandescent and fluorescent light sources.

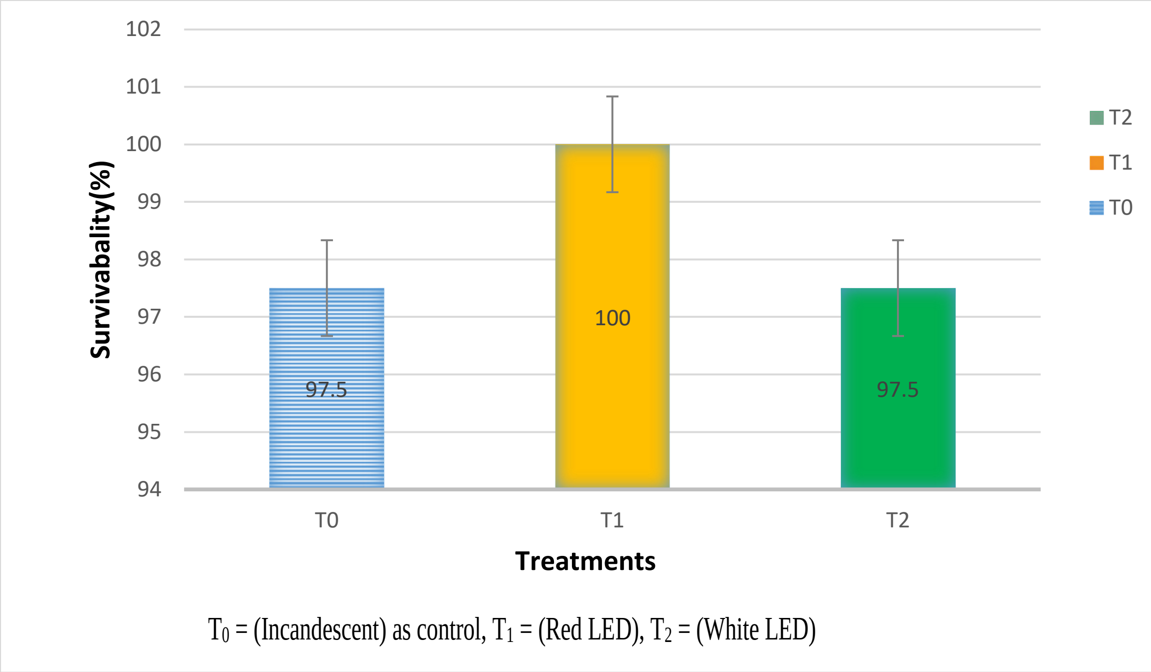


Fig 7: Survivability rate (%) of broiler chicken under different treatments

4.1.7 Dressing percentage

The dressing percentage of broiler chicken under different light color were 64.51± 0.75(T_2) which was significantly ($P<0.05$) higher compared to 62.8± 54(T_1) and 61.93±0.64 (T_0).

In the present study, the effects of LED light on broiler performance parameters including average dressing percentage (DP) was in agreement with previous studies (Woodward *et al*., 1969; and Bowmaker & Knowles, 1977). Furthermore, Newberry *et al*. (1988), who had illuminance values of 180 lux and 6 lux. The behavior of the broiler that was expressed by its level of activity was significantly influenced by the illuminance value of 180 lux, but the feed intake and water did not. The results regarding body weight, feed and water intake and feed conversion were not altered by different illuminances.

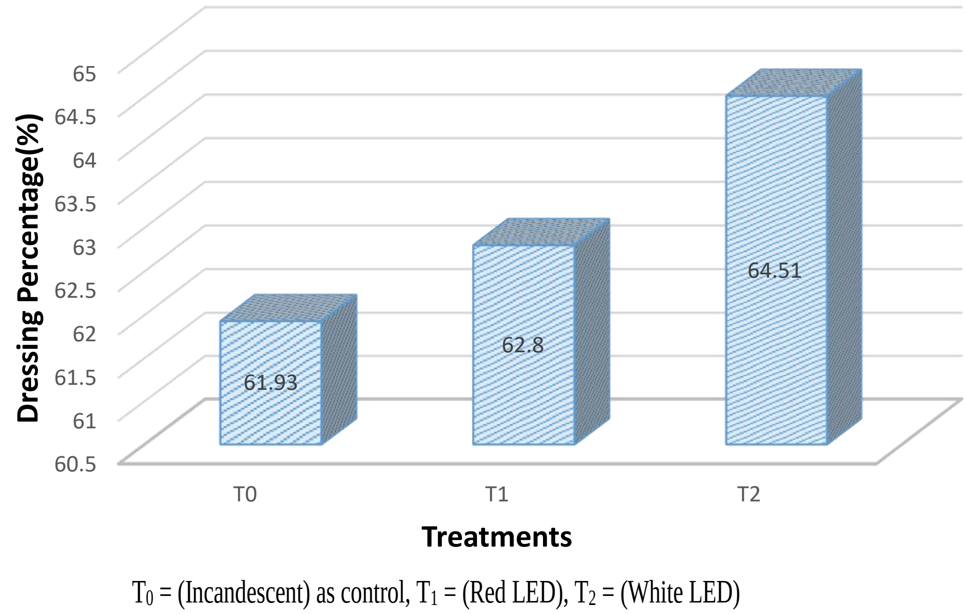


Fig 8: Dressing percentage (%) of broiler chicken under different treatments

Table 9: Effects of LED light on the dressing percentage of broiler chicken

Treatment	Average live weight±SE	Eviscerated weight±SE	Dressing percentage±SE
T_0	1977.50±24.62	1221.75±9.59	61.93^c±0.64
T_1	2060.00±97.55	1293.25±58.58	62.80^b±0.54
T_2	2038.25±52.45	1314.00±22.63	64.51^a±0.75
Mean±SE	2025.25±35.79	1276.33±22.55	63.08±0.47

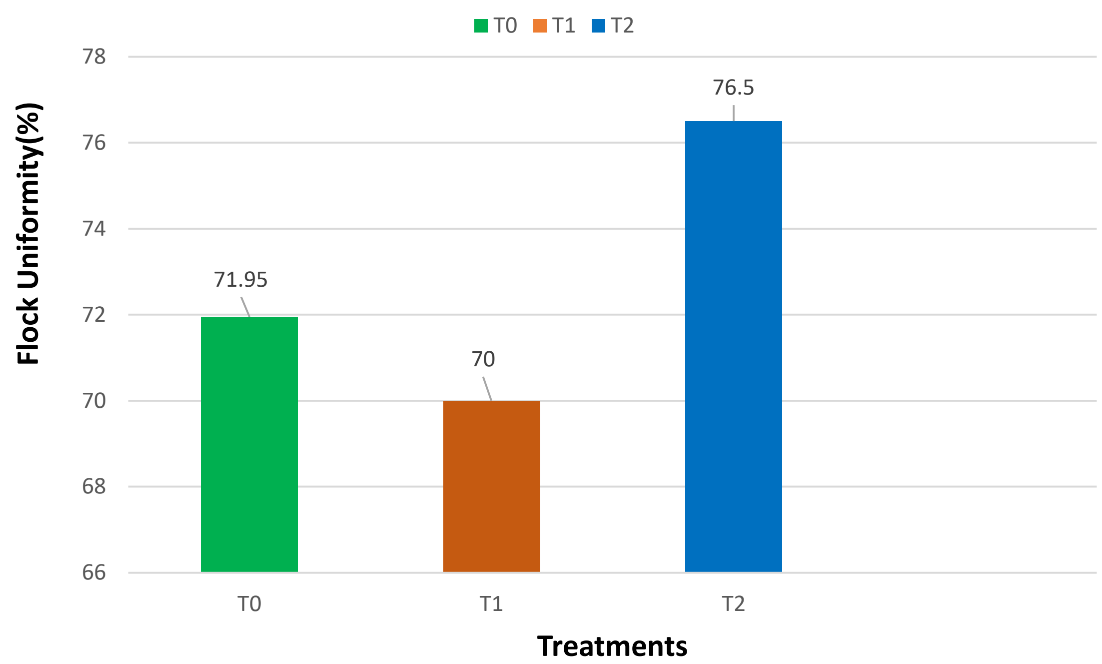
Here, T_0 = (Incandescent) as control, T_1 = (Red LED), T_2 = (White LED); Values: Mean ± SE; Applying: One-way ANOVA (SPSS, Duncan method)

- Mean with different superscripts are significantly different (P<0.05)
- Mean within same superscripts don't differ (P>0.05) significantly
- SE= Standard Error

4.1.8 Flock uniformity

Flock uniformity of broiler chicken were presented in table 10. The higher flock uniformity (76.5±7.81%) was found in T2 group. The lower flock uniformity (70±7.07%) was found in T1 group. Flock uniformity of different treatment groups were statistically insignificant (P>0.05).

The results are in good agreement with the findings of (Kristensen *et al.*, 2007) ;(Ozkan *et al.*, 2012); (Pan *et al.*, 2015); (Das & Lacin, 2014) and (Edward, 2003) evaluated the productive parameters of broilers raised in an environment illuminated by two distinct light sources. The results showed that there was a correlation between the uniform growth of the broiler and locomotive performance, but no influence of the ambient light on body weight, feed intake and mortality was observed. They concluded that the two sources of light at different lighting levels did not significantly affect locomotive and production parameters like uniformity. According to (Shabiha Sultana *et al.*, 2013) the uniformity (%) of broiler chickens has been previously assessed using monochromatic light, but no studies have been conducted to investigate the effects of LED mono and mixed light colors on broiler chicken. The enhancement in uniformity of T_1 group might be due to using red LED light of the birds flock.



T_0 = (Incandescent) as control, T_1 = (Red LED), T_2 = (White LED)

Fig 9: Flock uniformity of broiler

Table 10: Effects of different color LED light on uniformity of broiler chicken

Treatment	Uniformity±SE
T0	71.95±10.97
T1	70±7.07
T2	76.5±7.81
Mean±SE	72.87±4.66

4.1.9 Carcass weight

The carcass weight in T_0, T_1 and T_2 are showed in table 11 and figure 10. The results revealed that the treatments had significant effects in dressed Back, Thigh and Drumstick ($P<0.05$), but no difference in breast, wing and neck ($P>0.05$). However, in treatment T_2 group (White LED tube Light) the carcass weight is better than other treatment groups

The present study was agreed with the findings of Olanrewaju *et al*., 2015; Riber, 2015; Wilson *et al*., 1984 & Xie *et al*., 2009. They suggested that carcass, thighs, and drums yield, as a percentage of live weight, decreased linearly with increasing light intensity. Light intensity affected the percentage of remaining carcass (Breast, back and thigh), but a specific trend was not apparent.

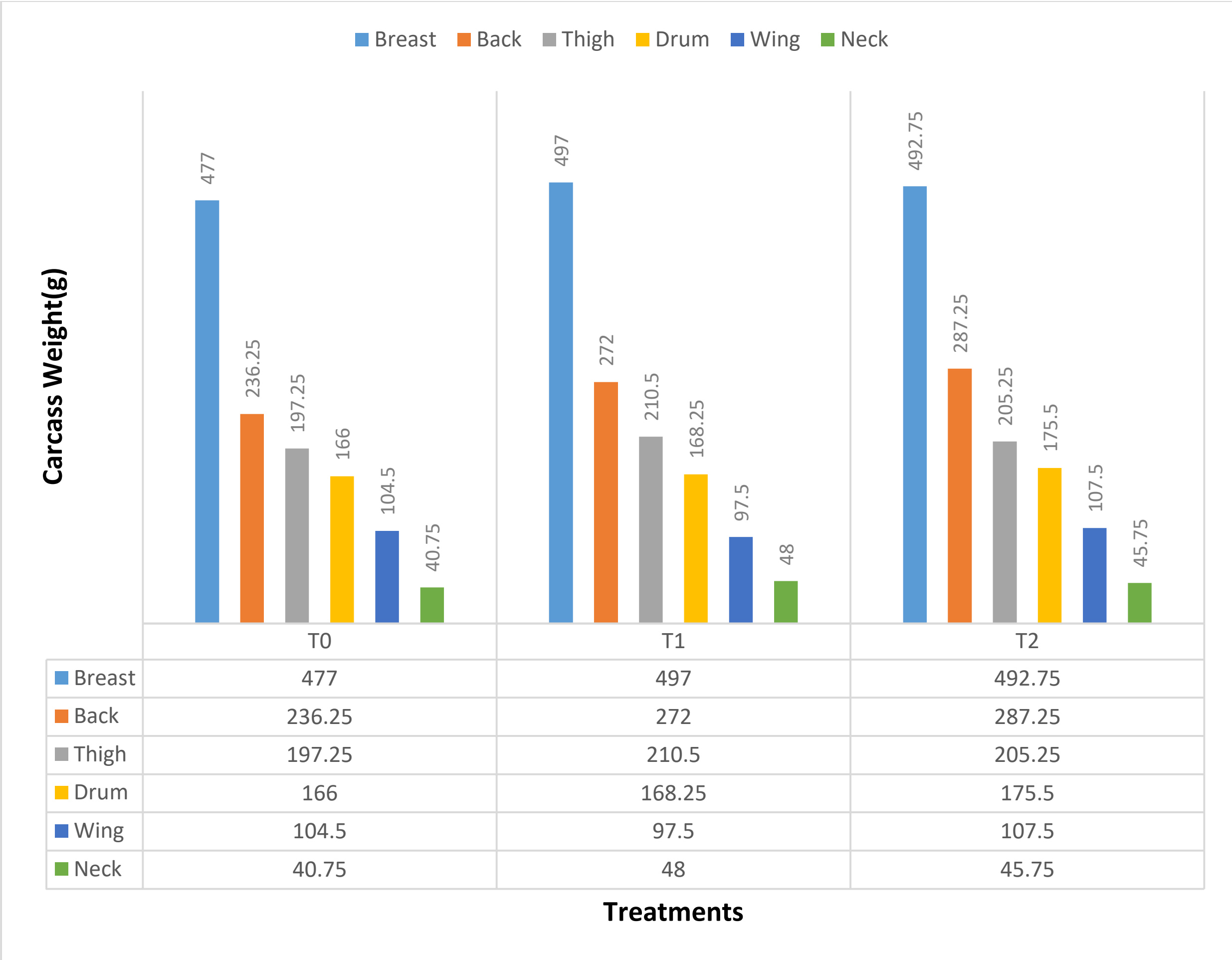


Fig 10: Carcass weight of broiler chicken under different LED light

Table 11: Effects of different color LED light on carcass characteristics of broiler chicken

Treatment	Breast±SE	Back±SE	Thigh±SE	Drum stick±SE	Wing±SE	Neck±SE
T_0	477±10.22	236.25^{c}±9.81	197.25±2.39	166±1.68	104.5±5.33	40.75±0.25
T_1	497±16.67	272^{b}±8.84	210.50±11.73	168.25±16.59	97.5±4.87	48.00±4.02
T_2	492.75±8.64	287.25^{a}±8.76	205.25±8.79	175.5±7.93	107.5±5.04	45.75±2.39
Mean±SE	488.92±6.94	488.92±8.02	204.33±4.77	169.92±5.70	103.17±2.94	44.83±1.68

Here, T_0 = (Incandescent) as control, T_1 = (Red LED), T_2 = (White LED); Values: Mean ± SE; Applying: One-way ANOVA (SPSS, Duncan method)

- Mean with different superscripts are significantly different ($P<0.05$)

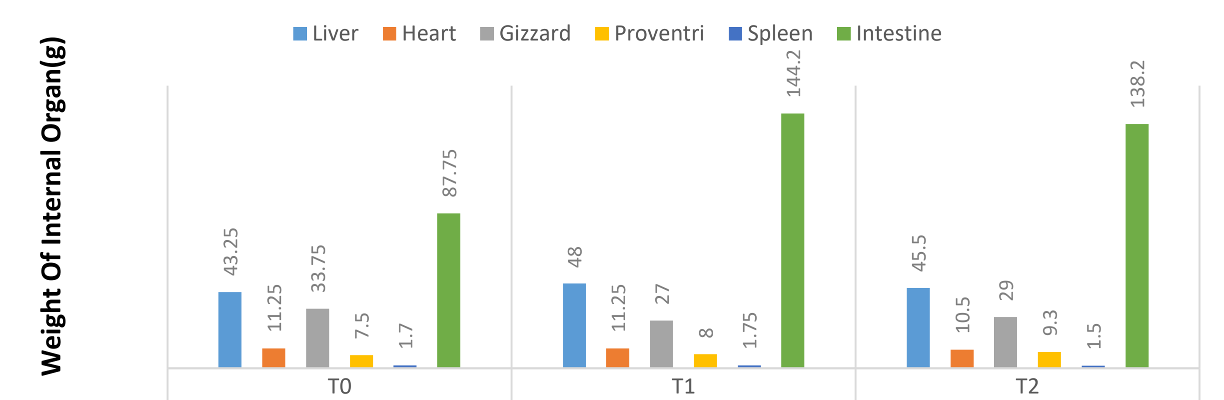
- Mean within same superscripts don't differ (P>0.05) significantly
- SE= Standard Error

4.1.10 Relative giblet weight

The relative weight of giblet organs (liver, heart, gizzard, proventiculus and spleen) in different treatment groups T_0, T_1, and T_2 groups are presented in figure 11 and table 12. The results revealed that the treatments had significant effects in liver, heart, proventiculus and intestine ($P<0.05$), but no difference ($P>0.05$) in gizzard, and spleen in different treatment group.

The relative weight of liver (g) of broiler chicks in the dietary group T_0, T_1 and T_2 were 43.25±2.49, 48.50±5.11, 46.50±1.44 and 45.2±0.86 respectively. The highest results were obtained in T_1 and lowest was in T_0 (Control) group. There was significant ($P<0.05$) difference in the relative weight of liver between the groups.

In the present study, the effects of LED light on broiler giblet weight was in agreement with previous studies (yang *et al*., 2016) ;(Sauveur & Morgin, 1983); (Weaver *et al*., 1982) and (Blokhuis, 1983).



	T0	T1	T2
Liver	43.25	48	45.5
Heart	11.25	11.25	10.5
Gizzard	33.75	27	29
Proventri	7.5	8	9.3
Spleen	1.7	1.75	1.5
Intestine	87.75	144.2	138.2

Treatments

Fig 11: Internal organ of broiler chicken under different LED light

Table 12: Effects of different color LED light on internal organ of broiler chicken under different treatment group

Treatment	Liver±SE	Heart±SE	Gizzard±SE	Proventiculus±SE	Spleen±SE	Intestine±SE
T_0	43.25±2.49	11.25±0.47	33.75^b±0.85	7.5^c±0.28	1.7±0.03	87.75^c±2.05
T_1	48±5.11	11.25±0.25	27^b±1.84	8^b±0.40	1.75±0.09	144.2^b±9.31
T_2	45.2±0.86	45.5±0.64	29^a±1.32	9.3^a±0.23	1.5±0.11	138.5^a±7.13
Mean±SE	45.58±1.83	11.00±0.27	28.92±1.26	8.28±0.28	1.69±0.05	123.42±8.44

Here, T_0 = (Incandescent) as control, T_1 = (Red LED), T_2 = (White LED); Values: Mean ± SE; Applying: One-way ANOVA (SPSS, Duncan method)

- Mean with different superscripts are significantly different ($P<0.05$)
- Mean within same superscripts don't differ ($P>0.05$) significantly
- SE= Standard Error

4.2 Cost benefit analysis

The cost benefit analysis of different treatment groups and control group presented in table 13. Total expenditure per bird was significantly ($P<0.05$) higher T_1 (172.97±1.52) group than control and other treatment groups. Feed cost is significantly ($P<0.05$) higher in T_2 group compared to control and T_2 group.

The price of five red LED light was 750tk where per light was 150tk and the price of three white LED tube light was 600tk where per light was 200tk. The electricity cost was higher in control group (T_0) compared to treatment groups. Profit per bird (PPB) was also presented in table 13, demonstrated the economic impact of the treatment groups compared with the untreated group. Return was calculated after selling the live birds per kg weight and profit was computed by subtracting the expenditure. Profit per bird was significantly ($P<0.05$) higher T_2 (79.92±2.83) group than control and T_1 groups. Net profit is higher in T_2 group due to low electricity cost. In this result, it seems that T_2 group was more profitable than other groups.

These results are in agreement with those of previous researchers Santana *et al*., 2014; Coenen *et al*. 1988; (DOE, 2009; Weinert *et al*., 1998 & Yahav *et al*., 2001 who found that rearing broiler chickens under LED light improved body weights than rearing under INCAN and CFL and indicated that LED caused a higher improvement in broilers net profit than control which given INCAN and CFL. Another researcher (Kristensen *et al*., 2007) where they found a significant increase ($P<0.05$) in net income value of supplemented group with LED light than control group

Table 13: Cost benefit analysis of different treatment groups (cost and profit per bird)

Treatment	Feed Cost (Tk)±SE	Cost of LED (Tk)±SE	Antibiotic Cost (Tk)±SE	Electricity Cost (Tk)±SE	Common Cost (Tk)±SE	Total Cost (Tk)±SE	Sell price(Tk) ±SE	Profit (Tk)±SE	Benefit Cost Ratio±SE
T_0	105.02 ±0.61	0.00 ±0.00	10.00 ±0.00	12.50 ±0.00	40.00 ±0.00	167.52 ±0.61	234.92^c ±1.88	67.41^c ±1.48	1.39^c ±0.00
T_1	106.72 ±1.52	18.75 ±0.00	0.00 ±0.00	7.50 ±0.00	40.00 ±0.00	172.97 ±1.52	241.03^b ±4.00	68.06^b ±2.98	1.38^b ±0.01
T_2	109.07 ±2.27	15.00 ±0.00	0.00 ±0.00	5.25 ±0.00	40.00 ±0.00	169.27 ±2.30	249.19^a ±2.08	79.92^a ±2.83	1.46^a ±0.02
Mean ±SE	106.93 ±0.98	11.25 ±2.44	3.33 ±1.42	8.41 ±0.91	40.00 ±0.00	169.92 ±1.09	241.72 ±2.29	71.79 ±2.17	1.42 ±0.01

CHAPTER-5
SUMMARY & CONCLUSION

CHAPTER 5

SUMMARY AND CONCLUSION

It is clear from the above discussion that light has an utmost role in poultry physiology as well as production. So, broiler production without proper light management is not recommended. A good light programming can improve the production traits like feed intake, body weight and feed-gain ratio and also poultry well-being which will result in more production with profit.

A study was designed to investigate the comparative effect of different color LED light on the productive performance of commercial broilers. A total of 120 day-old Lohmann broiler chicks were reared in Sher-e-Bangla Agricultural University Poultry Farm, Dhaka. Chicks were divided randomly into 3 experimental groups of 4 replications and each replication contains 10 chicks. These groups were allotted to three treatment designated as T_0, T_1 and T_2 group. Each treatment group is used for different color light.T_0 was offered Incandescent as a control group whereas T_1, and T_2 group were offered red LED and white LED light. In T0 and T_1 chamber 5 round blub is used for lighting whereas in T_2 group 3 tube light is used. Final live weight was insignificantly (P>0.05) higher in T_2 (1916.84 g) group than control group (1807.36 g). Total feed consumption was insignificantly (P>0.05) higher in T_2 (2478.81 g) than T_1 (2425.61) and control group (2386.85). Final FCR was comparatively better (P>0.05) in T_2 (1.32±0.02) than T_0 (1.35±0.00) and T_1 (1.34±0.02) group. Survivability of the chicken was non-significant (P>0.05) in different treatment groups and found higher in T1 (100%) group than T_0 (97.5%) and T_2 (97.5%) group. Average uniformity was significantly (P>0.05) higher in T_2 (76.50%) group than T_1 (70.00%) and T_0 (71.95%) group. Dressing percentage was significantly (P<0.05) higher in T2 (64.51%) group than T_1 (62.80%) and control group T_0 (61.93%). The present study showed that there was no significant (P>0.05) effect on heart, spleen and gizzard among different treatment group but there was a significant (P>0.05) effect on liver and proventriculus and found higher weight in T_2 than T_1 and T_0 group.

So, it is concluded that Incandescent light sources could be replaced with modern energy efficient light sources (white LED tube light) as indicated by overall performance of broilers for a profitable broiler production. The accommodation of broiler with a tubular LED lighting system did not change the animal performance when compared to the incandescent bulb lighting system.

CHAPTER-6

REFERENCES

CHAPTER 6

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CHAPTER-7

APPENDICES

CHAPTER 7

APPENDICES

Appendix 1. Recommended level of nutrients for broiler ration

Components	Starter ration	Grower ration
ME (Kcal/kg)	3000.00	3100.00
% CP	22.00	20.00
% Ca	1.00	0.85
% P (Available)	0.50	0.40
% Lysine	1.20	1.00
% Methionine	0.50	0.45
% Tryptophan	0.21	0.18

Source: Cobb 500 Broiler management guide 2016

Appendix 2: Recorded temperature and relative humidity (%) during experimental period

Age in weeks	Period	Average Tem. (ºC)	Average Humidity (%)
1st	03.11.19-10.11.19	32.2	64.3
2nd	11.11.19-17.11.19	28.0	69.0
3rd	18.11.19-24.11.19	25.5	66.2
4th	25.11.19-01.12.19	25.9	69.0

Appendix 3: Production performances of broiler under different treatment

Treatment	Replication	Final Live Weight (g/Bird)	Final Feed Consumption (g/Bird)	Total Body Weight Gain (g/Bird)	Final FCR	Survivability (%)
	R_1	1970.56	2393.44	1746.56	1.37	90
	R_2	1850.30	2421.50	1810.30	1.34	100
T_0	**R_3**	1799.60	2355.96	1755.60	1.34	100
	R_4	1789.00	2376.50	1745.00	1.36	100
	R_1	1905.50	2430.30	1861.50	1.31	100
	R_2	1777.50	2376.50	1733.50	1.37	100
T_1	**R_3**	1831.00	2374.10	1787.00	1.33	100
	R_4	1903.50	2521.56	1859.50	1.36	100
	R_1	1925.90	2466.56	1881.90	1.31	100
	R_2	1916.44	2628.11	1872.44	1.40	90
T_2	**R_3**	1874.00	2396.50	1830.00	1.31	100
	R_4	1951.00	2424.10	1907.00	1.27	100

Appendix 4: Weekly body weight Gain (BWG) under different treatment

Treatment	Replication	1st week BWG	2nd week BWG	3rd week BWG	4th week BWG	Total BWG
T_0	R_1	169	320	583	674	1746
	R_2	169	335	578	728	1810
	R_3	169	325	572	690	1756
	R_4	169	311	541	724	1745
T_1	R_1	169	331	572	789	1861
	R_2	169	323	536	706	1734
	R_3	169	324	546	748	1787
	R_4	169	306	614	771	1860
T_2	R_1	169	323	615	775	1882
	R_2	169	377	564	762	1872
	R_3	169	320	582	759	1830
	R	169	337	606	795	1907

Appendix 5: Weekly feed consumption (FC) under different treatment

Treatment	Replication	1st week FC	2nd week FC	3rd week FC	4th week FC	Total FC
T_0	R_1	191.70	418.44	739.44	1023.33	2393.44
	R_2	191.70	422.90	773.00	1034.00	2421.50
	R_3	191.70	408.80	726.50	1029.00	2355.96
	R_4	191.70	407.00	739.50	1039.00	2376.50
T_1	R_1	191.70	420.80	789.50	1029.00	2430.30
	R_2	191.70	415.00	731.50	1039.50	2376.50
	R_3	191.70	417.00	747.50	1019.00	2374.10
	R_4	191.70	422.90	793.00	1114.00	2521.56
T_2	R_1	191.70	422.90	768.00	1084.00	2466.56
	R_2	191.70	463.11	809.44	1143.33	2628.11
	R_3	191.70	425.00	741.50	1039.00	2396.50
	R_4	191.70	416.60	797.50	1019.00	2424.10

Appendix 6: Dressing percentage of broiler under different treatments

Treatment	Replication	Average Live Weight (g)	Eviscerated Weight	Dressing (%)
	R_1	1920	1220	63.54
T_0	R_2	1980	1196	60.93
	R_3	1970	1230	62.43
	R_4	2040	1241	60.83
	R_1	2110	1294	61.32
T_1	R_2	1800	1150	63.88
	R_3	2060	1292	62.71
	R_4	2270	1437	63.30
	R_1	2175	1365	62.75
T_2	R_2	1920	1259	65.57
	R_3	2038	1300	63.78
	R_4	2020	1332	65.94

Appendix 7: Uniformity of broiler under different treatment

Treatment	Replication	Uniformity (%)	Av. Uniformity (%)
T_0	R_1	77.78	71.95
	R_2	90.00	
	R_3	80.00	
	R_4	40.00	
T_1	R_1	50.00	70.00
	R_2	70.00	
	R_3	80.00	
	R_4	80.00	
T_2	R_1	100.00	76.50
	R_2	66.67	
	R_3	70.00	
	R_4	70.00	

Appendix 8: Carcass weight of broiler under different treatment

Treatment	Replication	Breast	Back	Thigh	Drumstick	Wing	Neck
T_0	R_1	476	215	203	165	120	41
	R_2	453	238	199	167	98	41
	R_3	503	230	192	162	103	40
	R_4	476	262	195	170	97	41
T_1	R_1	483	259	222	185	94	51
	R_2	465	260	178	122	88	37
	R_3	497	272	210	168	97	48
	R_4	543	297	232	198	111	56
T_2	R_1	501	277	222	197	118	50
	R_2	513	273	181	159	94	39
	R_3	476	287	205	175	111	46
	R_4	481	312	213	171	107	48

Appendix 9: Internal organ weight of broiler under different treatment

Treatment	Replication	Liver	Heart	Gizzard	Proventiculus	Spleen	Intestine
T_0	R_1	39	12	36	8	1.8	85
	R_2	44	11	34	7	1.82	89
	R_3	40	10	32	7	1.7	84
	R_4	50	12	33	8	1.85	93
T_1	R_1	49	11	27	9	1.9	158
	R_2	35	11	22	7	1.5	118
	R_3	48	11	26	8	1.7	144
	R_4	60	12	31	8	1.9	157
T_2	R_1	48	12	28	9	1.85	153
	R_2	44	9	29	9	1.3	143
	R_3	45	10	26	9.3	1.55	138
	R_4	45	11	23	10	1.5	119