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Effect of light management in broiler production: A review

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Abstract
In the last few decades, the broiler industry has grown very fast to meet the increasing demand for animal protein. 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 managemental 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, colour and source of light affect the production. Traits like feed consumption, feed efficiency ratio, egg hatchability, carcass yield, disease prevention trait and different economical traits can also be controlled by proper light management. So, the objective of this review is to discuss the role of light parameters in broiler production so that problems can be mitigated and producers could be economically benefited.

Keywords: broiler, light management, photoperiod, poultry

1. Introduction
The broiler industry is one of the fastest growing industries in India. With the rapid increase in population, the demand for animal proteins like chicken meat has increased drastically. 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. Consequently, this unidirectional selection has resulted in the development of many undesirable traits like an increased fat deposition, higher incidence of metabolic diseases, visual anomalies, skeletal deformities and circulatory problems [1]. These complications and the related economic losses caused by them have triggered the development of management techniques which will result in maximum productivity and minimize the problems. Management of light has emerged as one of the crucial managemental tools for poultry production. At the present situation, a number of lighting programmes (wavelength, intensity, and duration) and devices are utilized by the poultry producers. The potential use of photoperiod for better production and management is gaining interest day by day. This review briefly describes how light influences the production traits of broiler and also provides a direction to improve the production and the economy.

2. 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 [2]. It is important for sight both visual acuity and colour 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 [3,4]. Especially, light has an impact on the pineal gland and helps in synchronization of circadian rhythm and inhibiting melatonin release [5]. The circadian rhythm helps the bird to optimize their metabolism, physiology and behavioral pattern.

3. Light parameters affecting broiler production
3.1 Intensity of light
Light intensity has a strong impact on broiler behavior. In general, brighter light will result in increased activity, while decreased intensities are effective in controlling aggressive acts that

can cause cannibalism. Modern electronic systems are commonly used by the producers to increase light intensity for short periods during grow-out to increase exercise and thereby reduce skeletal and metabolic disorders. In the case of broiler, during the early part of life (1-7 day post hatch) a minimum light intensity of 20lx is used. Following the early period, the restriction of both light intensity and duration is a common practice. The intensity should be 3 to 5 lx and duration of 2 to 6 h/d for the rest of the grow-out period. Several researchers reported improved body weight (BW), feed intake feed-gain ratio (F: G) with low light intensities (1 and 5 lx) in contrast to birds given much brighter light (100 and 150 lx) as compared to 40 lx [6–8] Very bright light (100 and 150 lx) may stimulate the activity of broilers to the extent that they used more energy for maintenance and physical activities instead of growth. In contrast, some researchers have shown that, light intensity had no effect on overall broiler live performance, indicated by insignificant differences in average daily gain (ADG), BW, feed intake, feed-gain ratio (F: G) and mortality rate in case of young broiler chicken ((0-21 days) [9]; (0-35 days) [10].

Most carcass characteristics do not depend upon light intensity, but exceptions are thighs, drums, and wing yield as a percentage of live weight. Carcass yield decreases linearly with increasing the light intensity from 1 to 40 lx. Charles and coworkers found that dim light (5 lx) resulted in increased fat and decreased protein levels of the carcass and suggested that this might be due to decreased activity of birds kept in dim light [7]. Light is one of the most important factors regulating reproduction in birds. Adequate light intensity is required to stimulate receptors responsible for gonadotropin-releasing hormone (GnRH) release in the hypothalamus because these receptors are suggested to be sensitive to light directly passing through the skull instead of the perception of light by eyes [11]. Dim light (less than 5 lx) may not be able to penetrate the skull [12]; thus, the light at this intensity may be unable or less likely to excite receptors to release GnRH.

3.2 Light duration

Lighting duration, i.e., photoperiod, is the second major aspect of light that will alter broiler performance. Most research involving light management has focused on this factor. 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 [13]**.** Intermittent photoperiod significantly increases weight gain, feed-gain ratio, mobility and carcass yield with a decrease in mortality rate [14]. Lighting duration is largely dependent upon the age of the chickens involved and type of housing in use. A sample of lighting programme is given below (Table.1).

Table 1: Sample lighting programme recommendation for broilers [15]

Age (days)	Light Intensity (lx)	Photoperiod (L=Light, D= Dark)
0-7	20	23.0L:1.0D
8-14	5	16.0L:8.0D
15-21	5	16.0L:3.0D:2L.3D
22-28	5	16.0L:2.0D:4.0L:2.0D
29-35	5	16.0L:1.0D:6.0L:1.0D
26-49	5	23.0L:1.0D

Hours of day length have an important impact on growth rate with the effects being dependent upon marketing age. It has been seen that providing broilers with 20 hours of light a day gave the highest growth rate at all ages. As birds age, they are able to adapt to shorter day lengths. So, broilers marketed at older ages perform relatively better on shorter day length than birds marketed at younger ages. It has also been noticed that regardless of market age short day lengths (i.e. 14 hours of light) lead to a reduced growth rate. But, increasing day length to 23 hours a day also has a negative impact on the growth rate.

3.3 Darkness

Broiler lighting schedules can be characterized in a number of ways, including the number of hours of darkness and how many periods of darkness are included in each 24-hour cycle. Research has shown that darkness is as important to the growth and health of broilers as light [16]. The physical activity and walking ability are markedly improved when darkness is included in the lighting programme [5]. It is hypothesized that short photoperiods early in life will reduce feed intake and limit growth. Research comparing 12L:12D, 16L:8D and 20L:4D lighting schedules demonstrated clearly that longer periods of darkness prevent regular access to feed and consequently reduce feed intake and limit growth [17]. Furthermore, Classen and co-workers also compared lighting programmes with 12 h of darkness per each 24 h period provided in 1, 6, or 12 h intervals [18]. Their study indicated that the early growth rate was significantly reduced by longer periods of darkness, but gain from 14 to 35 d, as well as final body weight, were not affected by lighting programmes. Feed conversions were higher for 12L:12D and two 6L:6D periods per each 24 h period than 12 (1L:1D) periods per each 24 h period. The 12L:12D treatment resulted in lower mortality than the 12 (1L:1D) treatment and the 2 (6L:6D) was intermediate.

3.4 Colour of light

Colour 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) [19]. 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 [20,21]. Frequency of eating, intense sleeping, sitting and idling behaviors are more in blue light and green light promotes preening, dust bathing and drinking [21]. In this way, blue-green light stimulates growth in chickens, while orange-red stimulates reproduction [3, 22, 23]. Light of different wavelengths has varying stimulatory effects on the retina and can result in behavioral changes that will affect growth and development [21, 24].

Growth in broilers is affected by light spectra. Broilers under blue or green light become significantly heavier than those reared under red or white light [25]. Greenlight accelerates muscle growth and stimulates growth at an early age [26], whereas blue light stimulates growth in older birds [3, 22, 23].

The fiber diameter for breast and thigh muscle were found to be better for blue and green light compared to red light [27]. It is recommended that green light should be used up to day 17 and blue light afterward [27]. Some researchers have also used the mixed blue-green light system to increase broiler body weight [28]. In contrast, Hesham and co-workers partially supported these findings [21]. According to them, plumage conditions, the health status of the foot and toe and growth performance were not significantly affected by light colour though the parameters were better in case of blue light.

3.5 Source of light

There are different kinds of lamps available to poultry producers: incandescent, fluorescent, metal halide, high-pressure sodium, CFL (compact fluorescent) and LED (light emitting diode). All are in use in poultry facilities for laying hens, breeder flocks, broilers, and turkeys. No significant differences were found on weekly body weight, body weight gain and after treating the birds with different types of light sources- natural light, Incandescent (INC), CFL and LED [29, 30]. However, average feed intake was significantly higher in natural light and INC groups compared to CFL and LED. Similarly, the feed conversion ratio (FCR) was significantly higher in CFL and LED groups compared to INC and natural lights. So, it can be said that modern light sources like CFL and LED [both neutral LED and cool poultry specific LED (Cool-PSF-LED)] can be used in place of INC for more profit [4, 31]. In contrast, some researchers have found contradictory results. Rogers and colleagues reported that body weight was higher at day 42 when reared under incandescent lamps compared to cold cathode fluorescent (CCFL) [32].

4. Effect light on different traits

4.1 Feed Consumption and feed efficiency ratio

Feed consumption is also affected by day length. In general, the feed consumption response looks very much like that for growth rate. For all marketing ages, broilers were given 20 hrs light ate more than other treatments. As with growth rate, the comparison of 20 hrs light to 23 hrs light does not support the belief of many that more time for feeding always results in more feed intake. Since broilers prefer to eat during the day, it is expected that broilers were given days shorter than 20L would eat less and the data support this concept. As mentioned for the growth rate, the results also show that broilers adjust their eating behavior to compensate for the shorter day length as they get older. Feed efficiency is improved with decreasing day length (longer night periods); the best feed efficiency occurred when broilers were given 14 hours of light regardless of market age [33]. This improvement in feed efficiency is not due to differences in body weight gain but may be due to reduced maintenance requirements as a result of the lower metabolism that occurs during darkness.

4.2 Egg hatchability

It has already been proved that exposing embryos during incubation has an effect on hatchability [34]. An exclusive study was carried out by Archer (2017) on how the physiology of the broiler is affected by a different wavelength of light [35]. In this study, chicken eggs were incubated under dark, green light, red light or white light at the level of 250 lx. The result is described in the table below (Table.2).

Table 2: Effect of green, red and white light exposure during incubation of broiler eggs [35]

Criteria	Dark	Green	Red	White
Hatchability	-	-	Increased	Increased
Non-defect chick	-	Improved	Improved	Improved
Post-hatch 45-day weight	Not affected	Not affected	Not affected	Not affected
Feed conversion	Not affected	Not affected	Not affected	Not affected
Fear response during isolation	-	-	Reduced	Reduced
Tonic immobility	-	-	Reduced	Reduced
Humoral immunity	-	-	Higher	Higher
Plasma corticosterone	-	Lower	Lower	Lower
Plasma serotonin	-	Higher	Higher	Higher

These results show that white and red light has a positive effect on hatchability and also the health status whereas the green light is not that much effective. So, selection of light during incubation can be used efficiently for better productivity.

4.3 Carcass yield

Carcass yield was not affected by day length in broilers marketed early (31/32 days). At older marketing ages (38/39 and 48/49 days) carcass yield was found to increase with increasing day length. Breast yield increases with an increase in day length. But in older birds (those marketed at 48/49 days) there was no benefit of increasing day length beyond 20 hours of light. It was observed that increasing day length led to a linear reduction in drum meat yield but didn’t affect carcass fat content [33].

4.4 Economy

The role of intermittent lighting in improving production has been already discussed. But the saving of electrical energy through discontinuous lighting can’t also be neglected. It helps to reduce the cost of production and increase profit [14]. On another way, no additional investments are also not required for the implementation of a lighting programme [36].

4.5 Disease prevention

Footpad dermatitis is a multifactorial problem including various endogenous and exogenous factors [37, 38]. Previous research has shown that increasing broiler activity by reducing stocking density and providing a natural photoperiod resulted in decreased incidence of footpad lesions [39]. Blatchford and coworkers (2009) also found an increased incidence of hock and footpad erosions with dim light [40]. The increased incidence of ulcerative footpad lesions with decreasing light intensity is likely due to more time spent resting, thus resulting in increased contact time between the foot and litter as suggested by Blatchhford [40]. Another research also found increased resting at a low light intensity and therefore supports their suggestion [41]. The incidence of ulcerative lesions is of greater significance in the modern broiler industry because these wounds are undoubtedly painful and result in reduced welfare of broilers. The use of dim light 1 lx also caused a change in the anatomical structure of the chicken's eyes characterized by the incidence of buphthalmia, choroiditis, glaucoma, and lens distortion [10]. Photoperiod has an effect on immunoglobulin concentration in serum of broiler [42]. It was reported that broiler chicken (0-21 days) reared under intermittent lighting (17L:3D:1L:3D) have higher Ig-M concentration compared with constant lighting (24L:0D) [9]. It is well known that ammonia emission from the litter has a detrimental effect on broiler production efficiency and meat yields [43]. It was found that ammonia emission could be lowered if the birds are kept in dark or dim red light compared to high-intensity red light [44].

5. 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. Intensity, duration and colour are the three major factors that need to be adjusted with the increase of the advancing age of the birds. It is also proved that light management is important stating from incubation up to marketing. 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.

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