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IMPACTS OF VARIOUS LIGHTING PROGRAMS ON CHICKEN PRODUCTION AND BEHAVIOR – A REVIEW

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Abstract

Environmental changes have an impact on agriculture, especially the production of poultry. These changes have caused grave concerns that will negatively affect the health and productivity of chickens. We must consider illumination, density, and dietary aspects when determining the optimal environmental conditions for poultry rearing and output. Each of these variables influences the performance and behavior of birds uniquely. A crucial aspect of evaluating animal well-being is that it understands animal behavior. Artificial lighting has been widely investigated in poultry production over the last fifty years to enhance muscle gain and egg production while preserving an effective feed conversion ratio, bird health, and well-being. Yet, researchers and breeders still disagree over the ideal light quality and quantity, density, and feeding levels for poultry farming, particularly for chickens. This evaluation, therefore, covered the most up-to-date practical methods for enhancing illumination, density, and feeding-related aspects of poultry behavior, health, and production.

Key words: poultry, light, color, intensity, duration, behavior

In the modern diet, chickens are a significant source of animal protein. Poultry meat is a valuable food because it has a moderate caloric content, easily digestible proteins of excellent nutritional quality, unsaturated fats, B vitamins (primarily thiamine, vitamin B_6, and pantothenic acid), and minerals (such as iron, zinc, and copper) (Marangoni et al., 2015). To meet that demand, breeders must adopt new technology, allowing them to expand production at a lower cost with less detrimental environmental effects. Most of these production innovations concentrate on improving conventional inputs, including water, air, nutrients, and housing. More explanation of lighting and its properties is necessary to increase broiler production's productivity. Light is of essential relevance in poultry production since breeders want the poultry to reach its whole genetic potential in the best way possible. The light source, intensity, duration, and wavelength/color are all factors that affect how much light poultry receives (Olanrewaju et al., 2006; Çapar Akyuz and Onbasilar, 2018).

One of the essential aspects of poultry production is the environment. Light, which has a considerable impact on the birds' growth and development, behavior, physiological functioning, immune response, and growth rate, is one of the most crucial microclimate factors in the production of chickens (Zheng et al., 2013; Yang et al., 2016; Abu Ghanima et al., 2021). Researchers have been studying the impact of lighting on chickens for many years. Lighting, an outside factor, regulates several physiological and behavioral processes. Many important functions, including body temperature and various metabolic pathways that aid in feeding and digestion, are synchronized and established by light. Light also alters the secretion rhythms of several hormones that control growth, maturation, and reproduction (Olanrewaju et al., 2006).

Additionally, controlling physiological conditions, growth performance, behavior, and immunological response in birds is also thought to be significantly influenced by light, which is also a key environmental factor (Rozenboim et al., 2004; Xie et al., 2008). Electromagnet waves provide essential light for chickens, as their eyes weigh as much as their brains. Incandescent lighting has been the main source for birds, with recent use expanding (Appleby et al., 2004).

According to Firouzi et al. (2014), birds raised under yellow light performed better than those raised under

green light. The birds in the group raised under green light exhibited the slowest drop in maternal antibody levels and the greatest (insignificant) antibody titers for Newcastle disease (ND) compared to the other groups (white and yellow). According to Seo et al. (2016), an increase in the immune response can cut disease risk and treatment costs, reflecting higher rates of survival and lower production costs that promote profitability. They concluded that broiler immune function could be increased at the later production stage by employing shorter wavelength LEDs like pure blue and brilliant blue. They concluded that using pure blue and bright blue LEDs, which have shorter wavelengths, can enhance broiler immune activity in a later stage of development. Also, research suggests that light significantly impacts the behavior and function of chickens (Chiandetti et al., 2013; Letzner et al., 2014). Moreover, broilers kept under red light settings gained more weight and were preferred by birds to other light hues (Senaratna et al., 2016).

Sayin et al. (2022) found that the intermittent lighting group and the green-blue combination group had the worst outcomes for the fear reactions of broilers. The use of green monochromatic lighting for the first ten days of the fattening phase and blue monochromatic illumination for the subsequent time was found to have a good impact on growth and slaughter carcass traits. Yet, it was discovered that broilers raised under mixed green-blue lighting displayed high levels of fear.

In other studies, Podkowa and Surmacki (2023) indicated that the females strongly preferred the brighter nest boxes during their initial breeding attempt. Compared to nestlings raised in dark nest boxes, this group was heavier and exhibited higher immunological responses. Adult females making their first attempt at reproduction may benefit from nesting in brightly painted nest boxes. According to Ozkan and Simsek (2022), both intermittently restricted lighting systems (16L: 8D) can be used in broiler houses.

The impacts of various illumination schemes on productive efficiency and bird behavior were highlighted in this review article.

Perception of light in poultry

According to Kjaer and Sørensen (2002), light is a key factor in the evolution of aggressive behavior and feather plucking. If pullets are not beak-treated and laying hens are housed in cage-free setups, the risk and avoidance of these misbehaviors is a significant challenge. Thus, illumination must be a top priority when using good management techniques for poultry in enclosed facilities. First, it is important to recognize that the anatomy and physiology of the bird's and human eyes differ (Reese et al., 2009).

Light impacts poultry through two biological processes: visual perception and physiological changes in the birds. The bird can see images thanks to visual perception. The retina is an epithelial layer inside the eye containing photosensitive receptors, including rods and cones, for skotopic (at night) and photopic (during the day) vision. Also, light has significant physiological effects on various systems, including endocrine functions, circadian rhythm, and sexual behavior, according to Lewis and Morris (2000).

The eye has two useful components: The light waves are focused on the retina by the refracting structures, such as tear fluid, the cornea, anterior chamber, lenses, and vitreous body (Löffler and Gäbel, 2009). The rods and cones, the eye's photoreceptor cells, are found in the retina (Engelhardt et al., 2010). When exposed to light, photo pigments in the rods and cones cause structural changes. Following are a series of events that result in an electric signal. The retina's horizontal cells, amacrine cells, bipolar cells, and ganglion cells are all involved in connecting and transferring information to the brain via the optic nerve. According to Löffler and Gäbel (2009), the signal is sent electrically as a series of action potentials. In the brain, a picture of the environment is created. The ability to perceive images visually is a personal, acquired skill (Engelhardt et al., 2010). In humans, this process involves billions of nerve cells and more than 200 million sensory cells in the brain (Frings and Müller, 2014). Rods respond to very weak light impulses (a single photon). Unfortunately, they can only distinguish between light and dark because they cannot discern color (skotopic seeing).

The way fowl perceive light is completely different. Light can be seen in a variety of non-pictorial ways by chickens. Three key photosensitive zones are: (1) Photons are absorbed by photo-pigments rhodopsin (rods), iodopsin (cones), and melanopsin in the retina. (2) Pineal Gland – Photon absorption is accomplished by functioning photoreceptors in the pineal gland, which is positioned on the top of the brain. (3) Photon absorption by deep encephalic photoreceptors in the hypothalamus. Photoreceptors in various brain parts involved in photostimulation transduction receive light energy via the skull and tissues (Figure 1). The processes by which these events are mediated by serotonin and melatonin, which govern other endocrine functions and diurnal cycles, are well understood. These include locomotor activity, deep body temperature, migration, and seasonal breeding.

Photoreceptors in the eyes are not required for reproductive activities. Photoreceptors in the hypothalamus have been shown to act as biological transformers, converting photon energy into neuronal impulses. Females' reproductive and behavioural activities, as well as secondary sexual characteristics, are affected by these impulses, which alter the endocrine system that controls ovarian activity (Etches, 1994). Birds' vision is significantly superior to humans', as their color vision extends to the ultraviolet range (Honkavaara et al., 2002) and can see up to 330 degrees (Prescott and Wathes, 1999). Cone cells in the retina evaluate and send information to the brain, resulting in color vision. Aves have five different types of cone cells, including a double cone for ultraviolet vision.

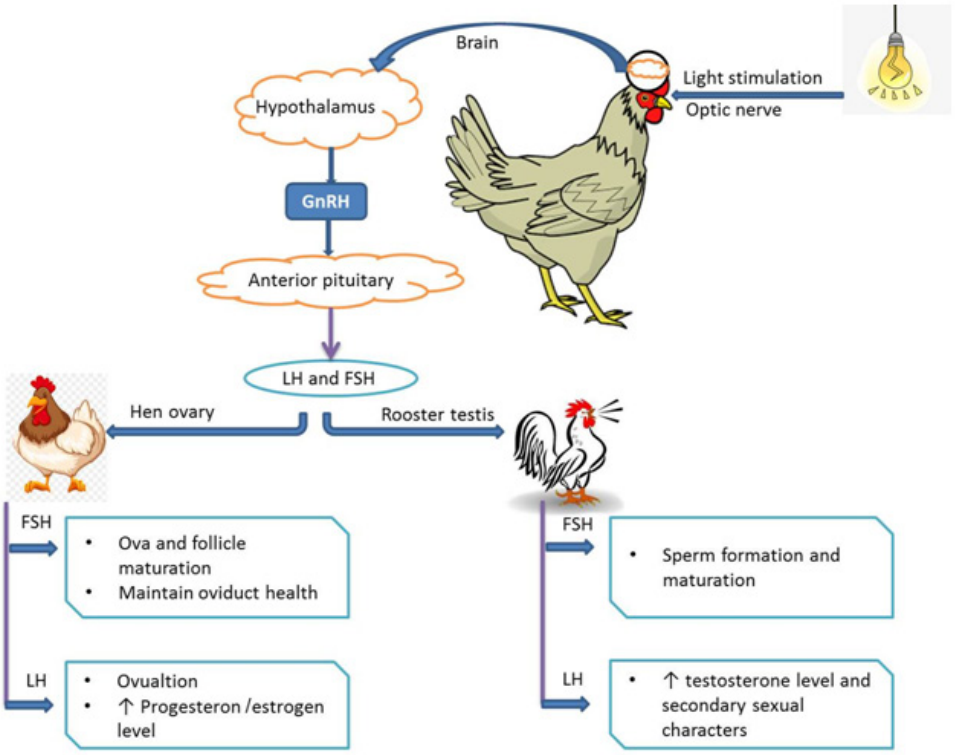


Figure 1. The mechanism of light stimulation in poultry

Importance of light in poultry production

Poultry production and administration have grown more specialized in maximizing profit and optimizing bird performance. Artificial lighting has been intensively investigated in poultry production over the last fifty years. Producers have sought to enhance muscle gain and egg production while maintaining an effective feed conversion ratio and bird health and well-being. The three components of light, which play a vital role in bird development and performance, have a substantial impact on the growth and well-being of the bird (Mohammed et al., 2010). These are the elements:

1) Illumination intensity (lux).

2) Photoperiod, the interval between dark and light in a repeated cycle.

3) The color or wavelength of the light emitted.

Light modification is an effective strategy for boosting chicken production (Table 1).

The level of light has a significant influence on broiler behavior. Brighter light generally causes more activity, but lower levels are good at reducing aggressive behavior that could lead to cannibalism. Producers frequently employ contemporary electrical systems to temporarily enhance light intensity during grow-out to increase activity and decrease skeletal and metabolic diseases. In the case of broilers, a minimum light intensity of 20 lx is utilized during the early stages of life (1–7 days post-hatch). Following the early phase, limiting the amount of light and its duration is customary throughout the remainder of the grow-out period. The intensity should be between 3 and 5 lx, lasting between 2 and 6 h/day. When pigeons were exposed to low light intensities (1 and 5 lx) as opposed to significantly brighter light (100 and 150 lx as compared to 40 lx), several researchers (Lien et al., 2008) found improved body weight, feed intake and feed conversion ratio. Broilers may become more active under very bright light (between 100 and 150 lx) to the point where they use more energy for survival and physical activity than for growth. The average daily gain (ADG), body weight (BW), feed intake, feed-gain ratio (F: G), and mortality rate for young broiler chickens (0–21 days: Zhao et al., 2019; 0–35 days: Deep et al., 2010) indicate that the light intensity had no significant impact on the overall life performance of broiler chickens.

Light is a significant external component that entrains the circadian clock, albeit other factors, including food consumption, impact clock signaling (von Gall, 2022). Layers detect the day via circadian rhythms and are most sensitive to light 11 to 15 hours after turning it on (Jácome et al., 2014). Reproductive functions are controlled by a neurohormonal system (Boni and Paes, 1999). As a result, light significantly impacts the growth and development of chickens. In environmentally controlled housing, artificial light is the only source for chickens. As a result, light supplementation source, spectrum, intensity, and regimen have all become important considerations in broiler management.

Table 1. Effects of different light programs on poultry

Parameters	Findings	Authors
1	2	3
Light intensity	The minimum light intensity required for maximum egg production in the layer is 5.38 lx in dark houses for layers.	Skouglund et al., 1975
	Body weight increased when broilers were reared at a light intensity of 5 lx.	Charles et al., 1992
	Low light intensities (less than 5 lx) can cause retinal degeneration, myopia, glaucoma, and damage to the lens leading to blindness.	Buyse et al., 1996
	Light intensities of more than 10 lx provide no additional benefits and may harm egg production.	Cotta, 2002
	No effects in body weight gain, leg health and broiler performance while exploring the impact of light intensity of 5 lx or 100 lx.	Kristensen et al., 2006
	Pigeons' body weight and feed intake feed gain ratio improved when they were exposed to low light intensities (1 and 5 lx) rather than much stronger light (100 and 150 lx compared to 40 lx).	Lien et al., 2008
	Broilers reared under 5 lx had greater eye weights than those raised under brighter light, suggesting possible inflammation or degeneration, which may support the theory that low light levels are inhumane and harmful to the welfare of birds.	Blatchford et al., 2009
	Due to less activity, broilers raised under low light intensity (1 lx) had greater body weights and breast meat yields.	McKee et al., 2009
	Very bright light (between 100 and 150 lx) may increase broiler activity to the point where they use more energy on maintenance and physical activity rather than growth.	Zhao et al., 2019
	The exposure to 0.6 lx resulted in a significant decrease in sperm count and percentage of live sperm and an increase in dead sperm percentage. The stress index rises due to the application to program 0.6 lx. Normal daylight yielded the best feed conversion ratios of 0.6 lx and 25 lx, respectively, in Japanese quails.	Maty et al., 2021
Light duration	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.	Classen, 2004 a
	Longer periods of darkness lowered the rate of early growth substantially. Nevertheless, lighting regimens did not affect weight growth from 14 to 35 days or final body weight.	Classen, 2004 b
	Birds with sufficient dark periods have fewer health-related problems, including sudden death syndrome, spiking mortality, and leg problems, than those maintained in continuous or near-continuous light.	Moore and Siopes, 2000
	Broilers exposed to restricted photoperiods had higher livability, average body weight, feed conversion rate, and percentage condemnations than broilers exposed to continuous light.	Classen et al., 1991; Classen, 2004 a
	Longer dark times were linked to lower mortality and better gait scores. The rationale for this impact was hypothesized to be reduced early growth, which enhanced leg strength.	Garner et al., 2005
	Chicks under CL (continuous lighting) are to be heavier than those under IL (intermittent lighting) in the first ten days. They also found that the feed conversion ratio was improved when birds were grown using intermittent lighting	Rahimi and Rezaei, 2005
	Longer photoperiods have been found to reduce mobility, exploratory, comfort and nutritive behaviors in broilers, while a photoperiod of 17 h produces maximum behavioral expression.	Schwean-Lardner et al., 2012
	Intermittent photoperiod increases weight gain, feed-gain ratio, mobility, and carcass production while decreasing mortality.	Arowolo et al., 2019

Table 1 – contd.

1	2	3
	The short day length (intermittent lighting) reduces energy consumption while improving broiler welfare.	Manfio et al., 2019
	The lighting length can substantially impact several aspects of broiler chicken behavior, including feeding activity, water consumption, scratching, resting, muscle and bone development, hormone synthesis, enzyme system activation, and immune system activation.	Olanrewaju et al., 2019; Soliman and El-Sabrout, 2020
	The light/dark cycle length is involved in key metabolic events and governing functions such as controlling body temperature, rhythmic and coordinated biological functioning, growth, maturation, and reproduction.	Pandey, 2019; Baykalir et al., 2020
	Several intermittently limited lighting programs can be used to illuminate broiler houses.	Ozkan and Simsek, 2022
Light color	Broiler birds raised under blue or green light had more satellite cells than those raised under red or white light, indicating that blue or green light promotes broiler growth.	Halevy et al., 1998
	Blue light has a calming effect on birds, while red will enhance feather pigments. Blue-green light stimulates growth in chickens, while orange-red stimulates reproduction.	Rozenboim et al., 2004
	Green light stimulates early growth, while blue light stimulates growth in older broilers	Cao et al., 2008
	Broilers reared under monochromatic green light (0–26 days) performed best, whereas those reared under blue light performed better in the next phase (27–49 days).	Chen et al., 2008
	The birds reared under yellow light outperformed those raised under green light. The decline of maternal antibody levels in the green light group was the slowest, and the birds had the highest ND antibody titers among the other groups at the end of the trial (white and yellow).	Firouzi et al., 2014
	Much feed intake and lower FCR in broilers reared under blue light and green light compared to white light treatment may be attributed to the calming effect of blue and green light where birds become less active	Mohamed et al., 2014, 2016
	Adopting shorter wavelength LEDs such as pure blue and brilliant blue can boost broiler immune function later in production.	Seo et al., 2016
	Keeping broilers under red light resulted in better weight gain and bird preference over other light hues.	Senaratna et al., 2016
	Rearing broilers under blue and green light for 23 h daily improves growth performance, physiological response, and welfare.	Mohamed et al., 2017
	Quails raised in red light had higher body weight at five weeks, relative growth rate, the first 42 days of egg production, relative ovaries and testicular weights, sperm motility and fertility, and hatchability percentages than those raised in green and white light.	Elkomy et al., 2019
	The use of red light illumination in an indoor laying duck-rearing system produced positive results in terms of egg-laying performance, appropriate egg weight, and egg quality compared to white and blue light.	Su et al., 2021
	The use of green monochromatic lighting for the first ten days of fattening and blue monochromatic lighting beyond that was found to have a positive impact on growth and slaughter carcass traits.	Sayin et al., 2022
	Mature females making their first reproductive effort may benefit from nesting in brightly colored boxes.	Podkowa and Surmacki, 2023

Table 1 – contd.

1	2	3
Light source	No differences in broiler performance when reared under incandescent or fluorescent light, but the replacement of incandescent light bulbs by fluorescent light resulted in significant electrical energy savings.	Schetdeler, 1990
	At the finishing phase, broiler chicks reared under fluorescent light gained more body weight, consumed less feed, and had a higher FCR than those reared under incandescent light (4–6 wk).	Hajra et al., 2009
	Feed consumption, body weight and total muscle weight values of birds reared under green and blue lighting groups were significantly higher than incandescent (control) lighting groups.	Karakaya et al., 2009
	Feed intake was much higher in the chamber equipped with white LED lights when hens were 21, 28, and 35 days old, and chickens grown with white LED bulbs outperformed chickens raised with CFL bulbs.	Mendes et al., 2013
	Improved FCR, platelet counts, and hematological responses in broilers grown under yellow LEDs versus incandescent light influenced growth performance.	Kim et al., 2013
	The growth performance of Pekin ducks can be improved by using red and blue LED, whereas meat quality traits can be improved in ducks by using green LED.	Kim et al., 2014
	Intermittent or continuous LED monochromatic lighting improves broiler body weight.	Astuti et al., 2015
	Birds reared under incandescent lamps weighed less after 45 days and had a higher FCR at 45 days than the birds reared under LED.	Huth and Archer, 2015
	Birds exposed to saving lamps had considerably higher body weights, weight growth, and FCR.	El-Hammady et al., 2014
	Birds raised under LED lighting have better FCR because the spectrum produced by LED bulbs nearly matches the spectral sensitivity of birds.	Nissa et al., 2018
	A properly staged spectrum control using LED lights could improve the immunological performance, bone development, and production performance of caged layer chickens during the brooding and raising phases.	Wei et al., 2020

Effect of light on layers performance

One of the most crucial elements influencing avian reproduction is light. Although it has been proposed that these receptors are responsive to light directly passing through the skull rather than the perception of light by the eyes, adequate light intensity is necessary to trigger gonadotropin-releasing hormone (GnRH) production in the hypothalamus (Robinson et al., 2003). Low light (less than 5 lx) may not be able to penetrate the skull (Morgan et al., 1995), making it impossible or less likely for the light to stimulate receptors and cause the release of GnRH.

Artificial lighting is frequently used to postpone or improve the initiation of egg production since the circulation levels of the luteinizing hormone (LH) and the follicle-stimulating hormone (FSH) increase within a single day of exposure to long photoperiods (Jácome et al., 2014). Many aspects of growth are affected by light, which must be considered when preparing to offer the most effective regulated environment for chicken production. Poultry performance experiments have examined the impact of various light sources, durations, intensities, and monochromatic and mixed light colors on chicken performance (Heshmatollah, 2007; Kim et al., 2012; Elkomy et al., 2019).

The use of proper lighting programs is crucial for egg production since the physiological reactions of the bird are directly influenced by the light stimulation. Light encourages egg laying, releases hormones involved in reproduction, and may hasten or delay sexual maturation (Freitas et al., 2005). While choosing the light source for laying quails throughout the egg-production stage, one should remember the advancements in ambient lighting technology and how well the lighting system balances cost and profit. The poultry industry may find light-emitting diode (LED) lamps a suitable lighting choice because they have lower energy consumption and a longer lifespan than standard incandescent and fluorescent lamps (Gongruttananun, 2011). According to studies, laying hens exposed to white light lay eggs that are heavier and have superior eggshell quality than hens exposed to green light (Er et al., 2007). However, Borille et al. (2013) did not notice significant variations in the quality of the eggs produced by layers exposed to various LED hues.

According to Nunes et al. (2016), Japanese quails exposed to red LED sources had identical live performance, egg quality, and reproductive and gastrointestinal tract parameters as those exposed to fluorescent lamps. Consequently, LED light sources, effective and sustainable alternatives, could replace fluorescent lamps in the lighting of Japanese quail houses for laying. Also, Shakeel et al. (2017) indicated that the Japanese quails with longer exposure to light had significantly better overall net profits than those with shorter exposure. According to Nasr et al. (2019), one of the three aspects of artificial lighting that has a substantial impact on the welfare, production, and reproductive success of chickens is light intensity. Quail welfare, growth performance, carcass characteristics, and meat quality were all improved by low light levels. Quails housed under low light conditions generated the heaviest egg weight and best egg quality.

Low light levels decrease the likelihood of unwanted behaviors and may make beak trimming unnecessary for the birds. However, significant changes in behavior patterns can be seen. In research by Thompson (2001), turkeys kept in lighting conditions of 2 or 5 lux were much less active and had minimal exploratory activity than those kept in lighting conditions of 10 or 50 lux. The lower the light intensity, the more preening was done. A varied light-intensity regime may reduce undesirable behaviors while maximizing welfare by allowing turkeys to express their full behavioral repertoire under the right circumstances. Also, turkey activity increased with bright illumination (25–100 lux), while turkey movement decreased with dim lighting (1–5 lux).

The impact of brightness in an avian species' nesting habitat could be extremely significant. It is well established that light impacts how young birds grow and behave. Because eggshells transmit some light waves to developing organisms, this process theoretically begins at the embryonic stage (Maurer et al., 2015). Exposing eggs to light during incubation is advantageous because it has been shown to hasten embryo development (Cooper et al., 2011; Austin et al., 2014), increase functional brain asymmetry, aid in the establishment of a circadian rhythm, activate antimicrobial defense mechanisms on the eggshell surface, and play a role in DNA repair during photoreactivation (Maurer et al., 2011).

Light intensity

Light intensity is important to consider while breeding broilers and layers because it greatly impacts their health and welfare. Light intensity has a significant impact on broiler welfare and behavior. Lower intensities (5 lux) successfully regulate aggressive behaviors that lead to cannibalism, while higher levels (50 lux) support increased activity (Mohammed et al., 2010). Because low light intensities impair movement and the capacity to see clearly when picking, they are supposed to help prevent cannibalism. Light intensity is increased for short durations during growth to increase exercise and reduce skeletal and metabolic diseases (Blatchford et al., 2009).

When broilers were reared at a light intensity of 5 lx, Charles et al. (1992) saw an increase in body weight. Low intensities have been linked to less wandering and standing, fewer fights, feather pecking and cannibalism (Buyse et al., 1996). Higher light intensities (above 5 lx) have been found in many field experiments to reduce body weight due to increased activity (Deep et al., 2010). Skeletal problems such as tibial dyschondroplasia and larger hocks were reduced in these investigations.

Most modern lighting regimens begin with high light intensity (20 lx), gradually decreasing to around 5 lx over 14 to 21 days and then remaining at 5 lx or less for the grow-out time in the broiler (Araújo et al., 2015). Reti-

nal degeneration, buphthalmos, myopia, glaucoma, and lens damage have all been associated with extremely low light intensities (less than 5 lx), all of which can lead to blindness (Olanrewaju et al., 2006; Frost, 2016). Because insufficient light intensity impacts egg production, a lux meter should be used in layer homes to determine light intensity properly. The lowest light intensity required for maximum egg production in a dark housing for layers is 5.38 lux (Jácome et al., 2014; Nasr et al., 2019; Kyere et al., 2021). According to Cotta (2002), 10 lux is required at the cage or bird's head height in open-sided houses. Light intensities of more than 10 lux provide no further benefits. They may harm egg production because they induce aggression, hyperactivity, and chicken cannibalism.

While investigating the impact of light intensity on broilers reared under 5 lux or 100 lux, Kristensen et al. (2006) found no significant variations in body weight gain, leg health, or broiler performance. Blatchford et al. (2009) investigated broiler behavior, eye, leg, and immunological health grown under different light levels, namely 5 lux, 50 lux, and 200 lux. They discovered that broilers were less active under 5 lux than the other two treatments. There were also no significant changes in weight growth across the various regimens. In addition, broilers raised under 5 lux had larger eye weights than those raised under brighter light, implying inflammation or degeneration, thus confirming that low light levels are harsh and deleterious to bird welfare (Raccoursier, 2016). In contrast, broilers raised under low light intensity (1 lux) exhibited larger body weights and breast meat yields, according to McKee et al. (2009).

In chicken farming, artificial illumination has been used to impact physiological reactions and metabolism and boost output. The three major components of artificial lighting are light wavelength (color), intensity (brightness), and lighting time (photoperiod) (Wei et al., 2020; Soliman and El-Sabrout, 2020). The impact of light is determined by a mixture of light sources, intensity, color, and photoperiod schedule (Parvin et al., 2014; Wei et al., 2020). The quantity (intensity) and quality (color) of light are two important aspects that influence poultry behavior and productivity (Elkomy et al., 2019). Also, Maty et al. (2021) reported that the intensity of white light had a distinct effect on the study parameters, with 0.6 lux harming the reproductive characteristics, the percentage of lymphocytes and heterophils and the stress index. However, 45 and 25 lux had a good effect on male quail component blood.

Light duration

The second important feature of light that will affect broiler performance is lighting duration or photoperiod. Most of the light management research has concentrated on this aspect. Over the years, various photoperiodic regimes have been used and studied. Almost all photoperiodic regimes are more advantageous for broiler production than traditional near-continuous lighting (Farghly et al., 2019). With a reduction in mortality, intermittent photoperiod dramatically boosts weight gain, feed gain ratio, mobility, and carcass production (Arowolo et al., 2019). The chickens' age and the type of housing used significantly impact how long the lights are on.

The duration of lighting can have a significant impact on various characteristics of broiler chickens, such as feeding activity, water consumption, scratching, resting, muscle and bone development, hormone production, enzyme system, and immune system activation (Olanrewaju et al., 2006, 2019; Soliman and El-Sabrout, 2020). Also, the length of the light/dark cycle is engaged in significant metabolic events and governing activities such as body temperature control, rhythmic and synchronized bodily functioning, growth, maturation, and reproduction (Soliman and Hassan, 2019; Pandey, 2019; Baykalir et al., 2020).

In broiler houses, non-intermittent and intermittent lighting programs are used. Non-intermittent illumination is a (near) 24-hour lighting program. It aims to maximize broiler growth by increasing feed consumption (Soliman and Hassan, 2019). Recent research (Hassanzadeh et al., 2012; Manfio et al., 2019) has shown that short-day length (intermittent lighting) saves energy and improves broiler welfare.

Broiler development and health depend equally on darkness and light (Classen et al., 1991). Short photoperiods are thought to restrict feed intake and inhibit avian growth in the early stages of life. Longer periods of darkness, according to current studies comparing 12L:12D, 16L:8D, and 20L:4D illumination programs, restrict regular feed access, reducing feed intake and limiting growth (Classen, 2004). Classen et al. (2004) investigated lighting schemes that supplied 12 hours of darkness every 24 hours at one, six, or twelve-hour intervals. According to their findings, longer periods of darkness greatly slowed the rate of early development.

Nevertheless, lighting regimens did not affect body weight gain from 14 to 35 days. Feed conversion rates were similarly higher for 12L:12D and two 6L:6D sessions spread over 24 hours. As a result, the gait score has been proposed as a marker for leg health and, consequently, broiler welfare (Sanotra et al., 2002; Garner et al., 2005). Broilers raised on a 2 (6L:6D) program until age 33 day had higher gait scores than broilers raised on a 12 (1L:1D) program, indicating more leg problems and poorer overall well-being (Charles et al., 1992). Longer periods of darkness have been linked to lower mortality and better gait. This impact is assumed to be caused by reduced early growth, which enhances leg strength (Olanrewaju et al., 2006).

In the first ten days, Rahimi and Rezaei (2005) discovered that chicks exposed to CL (continuous illumination) were heavier than those exposed to IL (intermittent lighting). They also discovered that growing birds in an environment with intermittent lighting enhanced feed conversion percentages. Increased photoperiod circumstances resulted in significantly higher weight gain and broiler hens' feed consumption (Lien et al., 2008).

Extended photoperiods have been demonstrated to limit broilers' mobility, exploratory behavior, comfort, and nutrition, whereas a 17-hour photoperiod encourages the highest behavioral expression (Schwean-Lardner et al., 2012).

On the other hand, according to other studies, melatonin increases the growth hormone in chickens and promotes feed conversion (Jia et al., 2016; Calislar et al., 2018). Melatonin hormone promotes live weight gain in animals by regulating their heat processes, energy metabolism, sexual maturity, and reproductive functions. It also protects them from heat stress, enhances their immune system, and plays a vital role in bone metabolism yields (Pandey, 2019). The epiphysis releases melatonin during the dark cycle and the retina during the light cycle; in fact, the epiphysis secretes 80% of melatonin into the blood circulation. Furthermore, it is secreted at modest levels by the epidermis, testicles, bone marrow, blood platelets, lymphocytes, and gastrointestinal tract. Also, the lengthy duration of darkness raises the melatonin level in chickens (Calislar et al., 2018).

Broilers that have been raised in the dark for an extended length of time are healthier than those raised in the light. Melatonin is a hormone produced in the pineal gland throughout the night that contributes to the circadian rhythm of body temperature and other essential metabolic activities in birds. Birds in enough darkness had fewer health issues, such as sudden death syndrome, mortality, and limb disorders, than those in constant or near-constant light (Moore and Siopes, 2000). Broilers raised on limited photoperiods outperformed broilers raised on continuous light regarding livability, average body weight, feed conversion rate, and percentage condemnations (Classen et al., 1991, 2004). As determined by plasma corticosterone levels, broilers subjected to intermittent photoperiods were less stressed than those exposed to continuous lighting (Puvadolpirod and Thaxton, 2000 a–d).

Long and sustained periods of light are not required for the layer. Adult chickens in lay neglect dark periods between 14–16 hours of light stimulation, according to the "subjective day" phenomenon. Even in the dark, the subjective day is when the bird is awake and physiologically active. This enables laying hens to be subjected to intermittent illumination schemes that involve numerous periods of light (photophase) and darkness (scotophase) during a 24-hour cycle (Gewehr and Freitas, 2007; Freitas et al., 2010).

Lighting programs for layers

The white LED and monochrome LED lights that are widely applied in poultry production (Hassan et al., 2013, 2014; Liu et al., 2018) likely do not meet the requirements for the welfare and health of layer chickens, especially for the brooding and rearing periods (0–20 weeks of age), when phased spectral control could be required to meet the growth of the immune and digestion system or skeletal and sexual development over the increasing chicken's age. Also, Wei et al. (2020) proved that phased spectrum control using LED lights could benefit pullets' growth and development. The blue-green light enhanced serum immunoglobulin (Ig) and serum glucose concentrations in layer hens during Phase 1 (0–13 weeks of age). At Phase 2 (14–20 weeks of age), the yellow-orange light raised bone mineral density concentrations, promoted sexual organ (oviduct and ovary) development, advanced the age of sexual maturity, and improved layer chicken output consistency.

Su et al. (2021) discovered the potential of using red light illumination in the indoor laying duck raising system with positive results on egg laying performance and acceptable egg weight, as well as comparable egg quality to white and blue light. Hemeral and ahemeral lighting programs are employed in layer manufacturing and are characterized by photoperiod. In Greek, hemera means "day". Hemeral lighting programs are made up of 24-hour periods separated into light and dark phases (photoperiod and photophase) (scotoperiod or scotophase). Open-sided dwellings that use natural light use ephemeral programs (Campos, 2000). Ahemeral illumination improves the quality and size of eggshells without impacting egg output. They are mostly used in climate-controlled facilities in Europe and the United States. Because daily duties must be completed outside of regulated working hours, such programs may increase labor expenses, which the production of larger eggs could offset. Photophases and scotophases that are shorter or longer than 24 hours are used in ahemeral regimens (Etches, 1996).

Cornell and biomittent programs are two examples of intermittent programs with names. Two hours of light (2L), 4 hours of dark (4D), 8 hours of light (8L), and 10 hours of dark (10D) are provided in the Cornell program (2L:4D: 8L:10D), which was established at Cornell University by Tienhoven and Ostrander (1976). The bird understands this program as 14L:10D, ignoring the four hours of darkness and considering a ten-hour night period. Thanks to the program, farmers may complete eight hours of work within the natural photoperiod. The biomatter lighting algorithm divides the time between alternate light and dark cycles into fractions (25 percent L: 75 percent D).

Light color

The third main factor influenced by wavelength is how it affects avian performance. Distinct wavelengths of light (400–700 nm) have different stimulatory effects on the retina and might cause behavioral changes in birds, altering their growth and development (Lewis and Morris, 2000). Wavelength significantly impacts poultry production and physiology, and it has recently been a hot discussion area. The color vision of domestic fowl is far superior to that of humans. Through retinal and deep brain, photoreceptors can recognize ultraviolet, blue, green, and red on the light spectrum (Prescott and Wathes, 1999; Kuenzel et al., 2015). Birds respond well to blue light, while red light enhances feather pigments.

In hens, blue-green light promotes growth, while orange-red light promotes reproduction (Rozenboim et al., 1999; 2004).

Broiler birds raised in blue or green light contain more satellite cells than those raised in red or white light, implying that blue or green light encourages broiler growth (Halevy et al., 1998). It was discovered that both blue and green boost growth, but the augmentation commenced at different times. Green light boosts early growth in broilers, while blue light stimulates growth in mature broilers (Rozenboim et al., 1999; Cao et al., 2008). The soothing effect of blue and green light, where birds become less active and less agitated, may be attributed to greater feed intake and decreased FCR in broilers versus white light therapy (Mohamed et al., 2014, 2016). Rearing broilers for 23 hours daily under blue and green light improves growth, physiological responsiveness, and welfare while lowering stress and fear responses (Mohamed et al., 2017).

Kumar et al. (2017) investigated LED bulbs (white, green, and blue). They discovered that LEDs might be a better alternative light source than conventional light bulbs without impacting Cobb broiler performance or carcass qualities. The results showed that the LED light treatment groups outperformed the incandescent light group regarding body weight, weekly body weight gain, feed intake, and feed conversion ratio. Furthermore, there was no discernible difference in carcass quality or yields.

Sayin et al. (2022) discovered that the intermittent lighting and green-blue combination groups had the worst results for broiler panic reactions. The use of green monochromatic lighting for the first ten days of fattening and blue monochromatic lighting beyond that was found to have a positive impact on growth and slaughter-carcass features. Yet, broilers grown under mixed green-blue lights showed high levels of fear.

The reason for red light's beneficial effect on egg production has been attributed to the fact that longer wavelengths (in the orange-red spectrum) penetrate the skin and skull more efficiently than shorter wavelengths (in the blue-green spectrum), resulting in improved reproductive performance in birds (Solangi et al., 2004). Broilers reared under monochromatic green light (0–26 days) performed best, whereas those reared under blue light performed better in the second phase (27–49 days). Blue and green light enhanced myofiber growth by stimulating testosterone release more effectively (Chen et al., 2008).

Red-light-reared hens laid eggs much earlier than incandescent and blue-light-reared hens. At the beginning of egg production, hens exposed to red light had an average lifespan of 2 to 11 days shorter than chickens subjected to all other light treatments (Khosravinia, 2007). Similarly, laying hens raised under red and white lights had earlier sexual maturity than hens maintained under green lights (Baxter et al., 2014). Also, light hue influences the number of eggs laid by laying chickens (Min et al., 2012; Baxter et al., 2014; Hassan et al., 2013).

Furthermore, the rise in ovarian follicle number due to increased serum follicle-stimulating hormone and luteinizing hormone concentrations when the red light is utilized could explain the improvement in average egg production (Hassan et al., 2013). Further research (Podkowa and Surmacki, 2023) found that females preferred brighter nest boxes during their first breeding attempt. Compared to nestlings raised in dark nest boxes, individuals in this group were bulkier and had stronger immune systems. Mature females making their first reproductive effort may benefit from nesting in brightly colored boxes.

Light sources

The effect of light sources on broiler performance, behavior, and welfare has been extensively researched. According to Olanrewaju et al. (2016), many bulbs are used in chicken production, the most common of which is the incandescent bulb. Several companies are developing new lighting technologies, such as cold cathode fluorescent lamps (CCFL), compact fluorescent lamps (CFL), and light-emitting diodes (LED), as potential replacements for incandescent light sources. These new light sources, particularly commercially available bulbs, are being studied for their impact on avian growth and production performance, well-being, and physiological responses regarding energy use, duration, and cost.

Roasters raised under fluorescent light had a reduced frequency of angular malformations and overall limb abnormalities than those grown under incandescent light (Lewis and Morris, 1998). Schetdeler (1990) found no changes in broiler performance when grown under incandescent or fluorescent light; however, incandescent bulbs were replaced with fluorescent light bulbs, resulting in significant electrical energy savings. Fluorescent light increased growth rate and enhanced bird feed conversion ratio compared to incandescent light. In the brain cortical region of birds exposed to fluorescent light, higher amounts of serotonin, epinephrine, and nor-epinephrine were discovered, indicating comfort compared to incandescent light (Korde et al., 2006). Ghuffar et al. (2009) discovered that the metal halide (MH) group had significantly higher body weight than the other treatments when studying the effects of various light sources on the performance of broiler birds, including incandescent light (INC), fluorescent light (FC), metal halide light (MH), and high-pressure sodium light (HPS). MH-raised birds consumed less feed and water than the other treatment groups.

During the finishing phase, Hajra et al. (2009) found that broiler birds reared under fluorescent light gained more body weight, used less feed, and had a higher FCR than those kept under incandescent light (4–6 wk). Compared to incandescent light (2.8 rupees/bird), the fluorescent light source reduced electricity costs and enhanced economic return (7.5 rupees/bird). The birds that were raised under fluorescent light were calm and collected.

The feed consumption, body weight, and total muscle weight of birds bred under green and blue lighting were

significantly higher than those kept under incandescent (control) lighting, according to Karakaya et al. (2009). Mendes et al. (2013) discovered that the light source (white LED vs. CFL) did not affect bird performance. The feed conversion of 7-day-old male chickens exposed to white LED lamps was found to be considerably lower. When hens were 21, 28, and 35 days old, feed intake was much higher in the chamber equipped with white LED lights, and chicks raised under white LED bulbs had better production performance than chickens raised under CFL lamps. Kim et al. (2013 b) found that broilers reared under yellow LEDs had higher FCR, platelet counts, and hematological responses than those reared under incandescent light, positively influencing growth performance. White light enhanced breast meat's essential and non-essential amino acid content among LEDs. During the early lay phase, LED illumination can reduce fear and stress behaviors, and the positioning and wavelength can also affect these reactions.

Furthermore, the findings revealed that reddish-hued LED lighting could increase the percentage of hens in lay at the beginning of the season (Archer, 2018). Moreover, Ahmed et al. (2019) indicated using LED lighting in broiler production to maximize profit and reduce costs. Light sources significantly impact productive and reproductive qualities, welfare aspects, hormonal profile, and overall economics of layer production, according to Raziq et al. (2021), with LEDs outperforming fluorescent and incandescent light sources.

Broiler body weight is increased by intermittent or continuous LED monochromatic lighting without an increase in plasma corticosterone or heterophil lymphocyte ratio, both stress indicators (Astuti et al., 2015). Birds grown under cold cathode fluorescent lamps had much lower body weights than those raised under LED and incandescent lamps. Kim et al. (2014) found that using red and blue LEDs increased the growth performance of Pekin ducks, whereas using green LEDs improved meat quality attributes in ducks. The birds reared under incandescent lamps weighed less after 45 days and had a greater feed conversion ratio than the birds bred under fluorescent lamps, according to Huth and Archer (2015). Nevertheless, the treatment groups had no significant difference in the feed conversion ratio (FCR) (Rogers et al., 2015).

Birds exposed to saving lamps had significantly higher body weights, body weight growth, and FCR than those exposed to incandescent lamps, as per El-Hammady et al. (2014). The body weight of broilers reared under natural (control), incandescent, CFL, and LED light did not differ significantly, as per Nissa et al. (2018). They also discovered that birds bred under LED lamps had a higher FCR. This could be because LED bulbs produce a spectrum that closely matches the spectral sensitivity of birds. The light sources, however, did not affect mortality rates.

Effect of light on poultry behavior

The purpose of lighting efficacy is to maximize production performance in broilers while also protecting bird well-being (Kim et al., 2013 a). Riber (2015) discovered no difference in any of the welfare metrics tested (scored gait, foot pad dermatitis, and hock burns) between the light treatments (neutral-white, 4,100 K and cold-white, 6,065 K). Hesham et al. (2018) discovered no significant variations in plumage scores or foot conditions between Fayoumi chickens grown under different light colors (yellow, red, green, and blue). The gait score of broiler chicks was unaffected by the light source or intensity (Kristensen et al., 2006). With Cobb broiler chickens, four colors of artificial light (red, white, green, and blue incandescent bulbs) did not affect welfare indicators, foot pad dermatitis, breast blisters, or hock burning damage scores (Senaratna et al., 2012). According to Kristensen et al. (2006), a rise in the body weight of broilers housed under blue light may deleteriously impact leg health.

Blue light has been shown to reduce stress (Xie et al., 2008) and fear reactions (Sultana et al., 2013) in broilers. Rearing broilers for 23 hours daily under blue and green light could boost growth performance and welfare by minimizing stress and fear responses (Mohamed et al., 2017). Blue LED lighting is preferred over other lighting colors in broiler houses because it calms the birds and substantially influences productive and physiological performance (Abdel- Azeem and Borham, 2018). Compared to standard white and red LED lights, blue LED light greatly improved the effectiveness of the Newcastle vaccine and significantly reduced intestinal bacterial burden (Soliman and Hassan, 2019). Nevertheless, green/blue mixed light may alter broiler metabolism and growth as a new effective technique for maximizing broiler growth performance by adopting mixed LED technology (Yang et al., 2016).

A person's or an animal's behavior can be defined as how they react to a specific situation or stimuli (Wood-Gush, 2012). Animal behavior is a good predictor of health. Playful, comfortable, and curious behaviors are pleasant behaviors that might help interpret an animal's feelings (including frustration, fear, or pain). Chickens are among the most researched poultry species, and researchers spend much time studying their behaviors. While the physiological and behavioral responses demonstrate how light impacts birds, broiler welfare is usually assessed by looking at their physiological aspects and their behavioral repertoire (Bizeray et al., 2002; Borille et al., 2013). Light intensity affects avian behavior (Alvino et al., 2009). On the other hand, exploratory activity is linked to the light's color (Huber-Eicher et al., 2013).

An extensive study is being conducted to determine the relationship between various elements of light and bird behavior. The birds raised in red light interacted more aggressively, pecking at the floor and expanding their wings than those raised in green or blue light (Prayitno et al., 1997). Different light sources also influence avian behavior. At six weeks of age, Kristensen et al. (2007) discovered that broilers preferred to conduct most

activities in surroundings lit by biolux and warm-white light, regardless of light intensity. Regarding avian behavior, LEDs in poultry buildings have yielded favorable results. When birds were bred under LEDs, they were calmer and less prone to feather plucking and aggression, and mortality was reduced by 0.5 percent (Hunt, 2009). Green LED-reared laying hens spend less time feeding and more time foraging than red and white LED-reared birds (Huber-Eicher et al., 2013).

The birds bred under fluorescent light showed an increased frequency of eating and preening activity (Santana Eich et al., 2016). Birds grown under fluorescent light and red LEDs were more active than those raised under blue LEDs. Nissa et al. (2018) found that CFL and LED light sources result in lower levels of plasma corticosterone and H:L ratio, both of which are stress indicators when compared to incandescent light and suggested that incandescent light sources be replaced with modern energy-efficient light sources (LED and CFL) for better broiler welfare.

Light helps the bird develop rhythmicity and synchronize many important functions, including body temperature and several metabolic steps that aid eating and digesting (Pal et al., 2019). Light also stimulates the release of hormones involved in development, maturation, and reproduction (Olanrewaju et al., 2016; Yang et al., 2016). It primarily affects the pineal gland, aiding circadian rhythm synchronization and limiting melatonin secretion (Deep et al., 2012).

Conclusions

With the current climate and economic constraints, environmental elements, including illumination, densities, and diet, have become crucial in poultry production. To optimize the profits of broiler chicken production, light wavelengths must be considered to maximize production profits. Compared to alternative lighting sources, LED lighting has been shown to be effective in enhancing the performance of meat chickens due to its homogenous distribution and diversity of colors. Recent improvements in chicken house illumination, density, and feed may impact the entire bird's life and personality traits. For instance, light control significantly affects birds during incubation through marketing. They can have long-lasting effects on birds' behavior, welfare, development, and growth. Good management and optimal husbandry programs improve bird behavior, health, and productivity, which boosts production profits.

Conflicts of interest

All authors declare that they have no conflicts of interest that could inappropriately influence this manuscript.

Author contribution

All authors contributed equally to writing this review article. All authors read and approved the final version of this manuscript.

Data availability statement

No data are available.

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