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LIGHTING SYSTEMS IN THE FIELDS OF LAYING HENS (THEIR IMPORTANCE AND IMPACT ON THE PRODUCTIVE AND IMMUNOLOGICAL) PERFORMANCE OF LAYING HENS

***Huda Falih Saad[1].**
Sabah K.M. AL-hummod2. Alfred Solaka Karomy3.
[1]PhD in Poultry Management, Animal Production, Faculty of Agriculture, University of Basrah.
[2]PhD in Poultry Management and Production, Animal Production, Faculty of Agriculture, University of Basrah.
[3]PhD in Poultry Feeding, Animal Production, Faculty of Agriculture, University of Basrah.
*Corresponding author email: huda.falih@uobasrah.edu.iq

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Abstract:

This comprehensive review explores the intricate relationship between lighting systems and the performance of laying hens, shedding light on their physiological, behavioral, and immunological responses. Acknowledging the pivotal role of light in avian reproduction, the study delves into its effects on ovary growth, follicle development, and, consequently, egg production. Optimal lighting conditions prove to be a crucial factor in maximizing poultry productivity and overall flock health. The article emphasizes the importance of understanding the intricate interplay of lighting duration, intensity, and spectrum in avian vision, elucidating how birds' unique visual apparatus responds to specific light wavelengths.

Keywords: Lighting systems, productivity, immunology, laying hens.

INTRODUCTION

Light significantly influences avian reproduction, enhancing the activity and effectiveness of birds (Olanrewaju et al., 2006). According to England and Ruhnke (2020), ovary growth and follicle development are intricately related to laying eggs in poultry. The longer the lighting, the more primary yellow oocytes there are and the heavier the ovaries get (Renema et al., 2001). This shows how important light is for controlling reproductive factors. However, the specific responses of these factors to distinct lighting schemes and photoperiods remain a subject of ongoing investigation. Light is pivotal in chicken production and management, directly influencing growth and productivity (Mohammed et al., 2010). Recognizing this, lighting programs are meticulously designed to meet the stringent requirements of poultry production standards (Lien et al., 2008). The acknowledgment of light as a central environmental element underscores its profound impact on avian reproductive processes, thereby guiding strategies for optimizing poultry performance. The interplay between light duration, intensity, and spectrum is a complex yet crucial determinant in achieving optimal outcomes in poultry egg laying. The influence of light on the bird is produced primarily through three components: the duration of illumination (photoperiod, wavelength) and intensity. (Soliman and El-Sabrout 2020).

THE IMPORTANCE OF LIGHT SYSTEMS ON PRODUCTIVE PERFORMANCE:

A proper lighting schedule for egg-laying birds aims to synchronize with the natural daylight changes, thus maintaining a uniform light distribution all year round. This is essential for the well-being and productivity of the hens.

The circadian rhythm of laying hens influences reproductive patterns, and optimal lighting systems can optimize light exposure, enhancing egg production rates, size, and onset.

Few studies have directly linked lighting to essential qualities like daily egg production, egg size, internal and external egg qualities, and others, even though many have examined the effects of illumination on laying hens' productive traits. We highlight a few of these studies below. Rana et al. (2023) carried out one such study. They found that exposing laying hens to various lighting durations at various ages in chickens exposed to natural forest light conditions at 18 weeks of age improved output levels, particularly between peaks and mid-production periods. However, the study indicated that UVA/B light supplementation did not significantly affect egg production. But U.V. lighting boosts hen-day egg output, affecting only the yolk index and eggshell reflectivity. Light supplementation may substantially impact egg production and eggshell quality in hens nearing the end of their production cycle or with a vitamin D3 shortage. Rana and Dana (2021a).

Light is very important for starting the ovulatory cycle in chickens because it stimulates extra-retinal photoreceptors in the hypothalamus. These photoreceptors, as identified by Bédécarrats in 2015, cause the release of gonadotropin-releasing hormones (GnRH-I and GnRH-II). According to research by Reddy et al. in 2012 and Baxter et al. in 2014,

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longer wavelengths of red light are specifically necessary for inducing the release of GnRH. Conversely, darkness prompts melatonin secretion, which, according to Tsutsui et al. (2000, 2010), stimulates the gonadotropin inhibitory hormone (GnIH), thereby preventing the release of GnRH. It's important to remember that light is not the only factor affecting hens' reproductive status, as Hanlon et al. explained in 2020. Other metabolic factors may also play a significant role in modulating the ovulatory cycle.

Furthermore, as England and Ruhnke (2020) thoroughly evaluated, more data is needed to determine the effects of UVA or UVB supplementation on egg production and quality during the laying cycle.

Another study by Wei et al. (2020) found that UVB light supplementation with LEDs improved egg generation in caged laying hens aged 68–75 weeks. However, it did not enhance egg quality or specific vitamin D metabolites. Egg shell quality and spreading efficiency were enhanced when vitamin D-deficient laying hens were exposed to UVB light for one hour daily. Lietzow et al. (2012). Egg production did not significantly increase in comparison to an 8-hour stationary control. However, exposure to progressive illumination for a year delayed sexual maturation and increased weight uniformity at 18 weeks, according to a study on phased lighting systems in small-scale commercial chicken farming (Leeson et al., 2005). Top of Form

Leeson and Summers (1985) found that early light stimulation in pullets reduced egg production up to 52 weeks of age compared to control birds. There were no changes in egg weight or shell quality after rearing. Also, they confirmed that photoperiod and early egg production may not necessarily correlate due to the confounding effects of the time and duration of adult photoperiod. Morris (1962) suggested that extending the photoperiod from 6 to 14 hours could hasten maturity by up to 14 days. Additionally, early light stimulation also reduced egg size. The study concluded that early light stimulation does not influence sexual maturity. Light intensity significantly impacts laying hens' sexual maturity, with bright light stimulating hormone production, white-colored quails enhancing maturity, and green light increasing ovarian and oviduct weight. Al-hummed (2020).

In a study by Lewis et al. (1996), the researchers pointed out the effect of photoperiods on the age at first egg in ISA Brown and Shaver 288 pullets. Results showed that birds reared on a constant 10-hour photoperiod matured earlier than those on 8-hour or 13-18-hour photoperiods. Changes in the photoperiod also affected food intake and the age of the first egg. The study concluded that pullets' sexual development responds more to photoperiod changes.

In this study, Lewis and his co-researcher (2007) compared Lohmann White and Lohmann Brown egg-type hybrids on different photoperiods and extended day lengths at 18 weeks. The results did not impact mortality; body weight gain and feed intake were positively associated. Lohmann White pulleys matured slower, but photoperiod raised eggs, weight, and shell strength. Feed intake, body weight, and egg quality were correlated.

Another study examined the impact of light intensities on Shaver White and ISA Brown pulleys' sexual maturity, feed consumption, body weight, and plasma luteinizing hormone concentration. The results showed that Shaver White pulleys matured later under constant illumination at 3 lux, while ISA Browns' sexual maturity remained unaffected. Feed consumption was higher at 3 lux but lower during rapid sexual development. (Lewis et al., 2004). Leeson et al. (2005) examined the effects of photoperiods on Leghorn pullets and young female chickens. Results showed that increasing photoperiods did not alter carcass composition or body weight. Early light stimulation led to fewer eggs, while 14-hour photoperiods increased feed intake and weight.

Er et al. (2007) studied the impact of light wavelengths on the quality of eggs laid by Hy-Line Brown hens. They used blue, green, and red lights for 19 to 52 weeks. Results showed that the W light had a higher egg weight, while the red light had a lower weight. Egg width decreased with maturity, while blue light had a shorter length and width. The green light had superior eggshell thickness and strength. Egg weight varies with light type, with incandescent light being the heaviest and red light suitable for small-sized eggs. Blue and red light shortens egg length and width, resulting in round or slender shapes.

An article on domestic chickens found no adverse effects on growth, food usage, reproductive performance, mortality, behavior, or live bird quality, suggesting fluorescent lighting may be better in certain situations. (Leeson and Summers, 1985).

A study involving 6144 laying hens from four breeds found that restricting consumption to a 6-week level during rearing from 6 to 14 weeks of age increased egg production and decreased egg weight. However, this had little impact on food consumption or egg production. Higher egg weights were linked to intermittent lighting, but lays, food consumption, and overall egg production decreased. Tucker and Charles (1993). Poultry's retina's four cone types affect their color perception, with greater sensitivity to blue and red light. Wavelength significantly impacts development and behavior, with red light inhibiting growth and stimulating sexual activity more than blue or green light. Lewis and Morris (2000).

Layer-breed birds were raised on litter and given an 8-hour photoperiod until they were ten weeks old. They were then placed in cages with varied light intensities. Birds under very dim lighting matured ten days quicker than negative controls but 20 days later than positive controls. This could be due to the highly dim light changing the biological clock or adding the first three hours of very dim light to the brilliant period. Caged pulleys' white light stimulation threshold ranges from 0.9 to 1.7 lx. The birds in the top tier reached the same age as the controls. Lewis et al. (1999). Low light

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levels can affect the biological clock's phase-setting, even without enough light for photostimulation. Bhatti et al. (1988) found that dim light is seen as darkness when bright and dim lights are switched. A mixed system of bright and dark light within 24 hours accelerates the biological clock's phase.

Lewis et al.'s (1997) study examined the photoperiods of 238 pullets at various maturity stages, including ISA Brown and Shaver. The amount and timing of the alteration determined the age of the initial egg, with ISA birds being more responsive than Shaver birds. Extended photoperiods resulted in more egg output from survivors but lower living conditions. When AFE was ten days later, the overall quantity of survivors' eggs decreased while the average egg weight increased. AFE did not affect Shaver birds' egg production, while it harmed ISA birds. During sleep, daylight hours also raised average daily food consumption; however, a 10-day delay in AFE decreased food consumption. After every ten days in AFE, food efficiency in conversion increased. Additionally, the condition of the eggshell declined with light periods.

Wei et al.'s 2020 study found that UVB exposure to laying hens increased egg production by 10% to 19%, but the cause remains unknown. The study also found no significant changes in eggshell thickness, weight, egg weight, or egg yolk weight, suggesting eggshell stability and thickness remain unaffected. According to England and Ruhnke (2020), commercial laying hens typically only produce one cycle of eggs since their quality and quantity decline at 70–80 weeks. Enhancing or preserving egg quality and applying persistence may positively affect the economy, the environment, and the egg industry's sustainability. Modern laying hens depend on light sources for optimal laying performance, and artificial lighting systems regulate the eggs produced. While U.V. light activates cholecalciferol in the skin to improve the quality of the eggshell, red light stimulates the hypothalamus to increase egg production.

Barros et al. (2020) compare laying hens' productivity and egg quality using a linear LED strip lighting system to conventional LED lamps in this study. Results show that LED strips significantly improve egg production compared to lamps, while egg quality remains unaffected. The study suggests that homogeneous illuminance distribution from LED strip lighting enhances egg production.

Investigates this researcher, Osadcha and Sakhatsky (2021), about the impact of monochrome light on egg production efficiency in laying hens. Four groups of hens were housed separately, with LED lamps as the only variable. Over 44 weeks, daily assessments determined the European egg production rate. The study found that maintaining laying hens in 12-tier cage batteries with a peak wavelength of 653 nm was most effective, resulting in an additional 4.8–18.8 million eggs per poultry house. However, decreasing the peak wavelength negatively affected livestock preservation, body weight, initial laying hen productivity, and feed consumption.

In the same study above, the researchers found that laying hens using linear LED strip lighting had higher egg production after the peak lay (28–48 weeks) than those using LED lamps. The hens with LED strips had higher egg production in the 31–33 and 46–48 weeks of age and tended to have higher egg production in the 40–42 weeks compared to LED lamps. Lighting systems did not differ before the peak lay.

Researchers observed that the chickens were kept in eight pens and taught for 26 weeks, either with or without nest illumination. The impact of four different nest curtain configurations on the dispersal of chickens was assessed at 27 weeks of age. In addition to decreasing damaged and unclean eggs, using illuminated clutches boosted the percentage of egg laying and the number of eggs deposited inside the nests. Nests with red and yellow curtains at the first and second tiers and nests with yellow and red curtains at the first and second tiers, respectively, showed an increase in the number of chickens on the ground and ground eggs in pen curtains at all tiers when there were yellow nesting blinds present. As a result, nest illumination encouraged increased egg production and hen usage.

The experimental LED did not significantly affect egg production, but the blue LED increased Pulley's body weight and lay. Red-LED birds had higher yolk weight and reduced albumen weight, which is potentially beneficial for food items like mayonnaise. Blue LEDs increase body weight and lay earlier, but this conclusion is challenging due to potential adverse effects (Poudel et al., 2022). In their 2023 study, Bahuti et al. looked at how the bodies of 25–36-week-old Hy-line W-80 laying hens responded to different levels of LED lighting, their productivity, and how good their eggs were. The birds were divided into three flocks, each lasting 28 days, and the experiment was conducted in climate-controlled wind tunnels. Results showed no effect on egg quality or birds' responses, but exposure duration affected body mass, albumen percentage, feed intake, cloacal, and surface temperatures.

Saad et al. (2023) indicated a significant effect of light color on the performance and productivity of poultry chicks at 35 days old. They observed that birds exposed to green and blue and the mixture of blue and green colors in comparison with the white color lighting range have different impacts.

THE IMPORTANCE OF LIGHT SYSTEMS ON THE IMMUNITY INDEX OF LAYING HENS

Lighting programs significantly impact chicken health and immunity, with scientific studies highlighting the connection between lighting conditions and chicken immune responses and emphasizing the importance of proper illumination in poultry farming.

Because lighting programs alter laying hens' circadian rhythm (Appleby et al. 2004), they significantly affect their immunity. Like other living things, chickens have developed in response to natural day-night cycles, and any

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disturbances can substantially impact their physiology. Sufficient illumination facilitates the synchronization of this rhythm, modulating multiple physiological functions, such as the immunological response. Consistent lighting schedules positively affect the immune system of laying hens, enhancing the production and activity of immune cells like lymphocytes and macrophages. Modulating melatonin secretion, influenced by light-dark cycles, has also been linked to improved immune function.

Lighting programs can indirectly affect laying hens' immunity by influencing behavior, activity, and stress levels. Suitable lighting conditions lead to natural behaviors, reduced stress, and a strengthened immune system. (Florentino Pereira et al., 2017; Geng et al., 2022). Chickens raised for poultry are subjected to various potentially stressful situations, including extended periods of light. Stressors are well documented to impact the immune system negatively. However, a healthy and well-functioning immune system is necessary for high productivity, safe animal products, and the well-being of chickens. (Hofmann et al., 2020).

The impact that lighting—including intensity, duration, lighting system, and lighting period—has on the productivity of laying hens makes lighting one of the most important factors in poultry farms. The health of laying hens is one of the primary variables that can be indirectly impacted, as there are several indicators of their health, such as elevated or decreased lymphocyte counts in the changed cells or high levels of the stress hormones cortisol or adrenaline. Blatchford et al. (2012).

Past research has demonstrated that light hue influences poultry immune function, with blue light being revealed to boost the immunological response. This may be because blue therapy relaxes chicken behavior and can mitigate the detrimental consequences of stress. In addition, blue light has the potential to significantly boost chicken immunity, especially in the early stages of the rearing and laying phases. (Xie et al., 2008)

Studies (Moore and Siopes, 2000; Onbaşılar et al., 2007) show that while daily light-dark cycle therapies can improve humoral and cellular immune responses in adult starlings, prolonged exposure to light can depress immune function. When exposed to intermittent lighting instead of continuous lighting, broilers' antibody titers against the virus causing Newcastle disease were higher. The impact of light hue on the immunological responses of avian species is, however, little understood. The researcher Wei et al. (2022) concluded through a study carried out earlier that there were no significant differences in IgG concentration levels in pullets between different treatment groups at 7 and 20 weeks of age. This contradicts a previous study (Xie et al., 2008; Cao et al., 2008; Hassan et al., 2013) that found the immune function of hens in red light groups was more significant than in green and blue light groups. The main reason could be differences in light sources, photostimulation time, and chicken breed. However, at 13 weeks, IgG contents from the BGL and BG-YOL groups were higher than those from the W.L. group, confirming earlier studies showing how light color affects poultry immune function.

Studies have indicated that birds raised in red light are less likely to be stressed out and to recognize others in social situations than birds raised in white or blue light. D'Eath and Stone's (1999) research indicates that laying hens grown in red light have a lower mortality rate of 12.65%, whereas hens raised in blue light have a higher mortality rate of 14.30%. These findings show that hens raised in red light are less susceptible to stress. Svobodova et al. (2015).

According to the results of the Archer (2018) study, the plasma corticosterone, heterophil to lymphocyte ratio, and composite asymmetry score of birds initially displayed similar stress responses. However, at 42 weeks, birds exposed to red light (RED) exhibited lower stress responses across all measures. This trend continued at 72 weeks of age, aligning with unpublished data from Archer and Byrd, suggesting that birds in the early laying phase exhibited lower stress responses

CONCLUSION

Lighting conditions impact laying hens, which is vital for hen productivity and health, and the hormonal balance and behavioral traits of laying hens influence their sexual maturity. More research is required to understand these immunological characteristics

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