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Impact of the Light Colors on Embryonic Development, Hatchability, Chick Quality in Broiler Chicken

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ABSTRACT

Light plays a crucial function in the bird embryo's growth and development, and its absence may lead to failure-hatching or embryo deformity. Thus, the investigation aimed to determine the significance of light colors on chickens' growth and embryonic development. This investigation was performed at the College of Agricultural Sciences, University of Sulaymaniyah, Iraq, to examine how light colors impact embryonic development, Hatchability, and hatched chick quality. Four treatments were used: Dark without light (control) (D), red light (RL), blue light (BL), and green light (GL), with three replications (25 egg/replicate). In total, 300 eggs (ROSS 308) were fertilized, and 75 eggs were laid in each incubator (each treatment in the incubator separately; the incubators were similar in all circumstances). The outcomes showed a considerable increase ($P<0.01$) in the embryonic development of the embryo length (mm) at the first stage of incubation, age of three days, as well as a considerable increase in the vascular area (mm) development and the No of somites pairs if all the experimental treatments exceeded the D. The treatment of the whole experiment in the ratio of the weight of the embryo on D as well as a meaningful improvement ($P<0.01$) in the albumin and yolk weight for the treatments. There was a considerable expansion in the hatchability ($P<0.01$) and the quality for all the investigation treatments in comparison to the D. In conclusion, using light during the embryonic period will affect embryo development, embryonic traits, hatchability, and chick quality.

تأثير الإضاءة المختلفة على النمو والتطور الجنيني وقابلية الفقس ونوعية الافراخ الفاقسة في فروج اللحم

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الخلاصة

الضوء يؤدي دورًا حاسمًا في نمو وتطور أجنة الطيور، وقد يؤدي غيابه إلى فشل عملية الفقس أو تشوه الجنين. هدفت الدراسة لمعرفة أهمية الضوء وألوانه على نمو وتطور الجنيني في الدجاج. أجريت هذه الدراسة في كلية العلوم الزراعية جامعة السليمانية – العراق، لدراسة تأثير الألوان الضوئية المختلفة على النمو والتطور الجنيني ونسبة الفقس ونوعية اللافراخ الفاقسة. تم استخدام أربع معاملات كانت على النحو التالي: الظلام بدون ضوء سيطرة (D)، الضوء الأحمر (RL)، الضوء الأزرق (BL) والضوء الأخضر (GL)، مع 3 مكررات لكل معاملة (25 بيضة/مكرر)، في المجموع 300 بيضة (308 ROSS) مخصبة، ووضعت 75 بيضة في كل حاضنة (كل معاملة في الحاضنة على حدة، الحاضنات كانت متشابهة من حيث جميع الظروف). أظهرت النتائج زيادة معنوية ($P<0.01$) في التطور الجنيني لمنطقة الشفافة وطول الجنين في المرحلة الأولى من الحضن عند عمر 3 يوم وكذلك زيادة معنوية في تطور المنطقة الوعائية وعدد البدينات N اذا تفوقت جميع معاملات التجربة على معاملة السيطرة بدون ضوء D. اما في المرحلة الجنينة الثانية وعند العمر و7 و14 و17 يوم فقد تفوقت ($P<0.01$) معاملة التجربة جميعها في نسبة وزن الجنيين على معاملة السيطرة D وكذلك تحسن معنوي ($P<0.01$) في وزن البياض والصفار بالنسبة للمعاملات التجربة, وكان هناك زيادة معنوية في نسبة الفقس ونوعية الافراخ الفاقسة لجميع معاملات التجربة مقارنة مع معاملة السيطرة D. وفي الختام، فإن استخدام الضوء في الفترة الجنينية سوف يؤدي إلى تطور الجنين والصفات الجنينة ونسبة الفقس ونوعية الافراخ الفاقسة.

الكلمات المفتاحية: اضاءة مختلفة، طول الجنين، نسبة الفقس، وزن الجنين وطول الجنين.

INTRODUCTION

Recently, curiosity about environmental factors influencing embryonic evolution and growth in mammals and birds has expanded. As an environmental factor, light recreates a meaningful role in controlling the biological cycles of adult organisms and the embryo's development (Dishon *et al.,* 2017). Earlier investigations have indicated that light can instantly impact growth rates, organic development, and innate manners in various organisms. In poultry farming, the chicken embryo is a valuable examination model for understanding how light influences developmental operations due to the essence of chicken as a food source worldwide (Mehlhorn & Caspers, 2021).

Despite earlier investigations showing that light can influence embryo growth and development, there are gaps in understanding how different light colors impact physiological and embryonic development (Rozenboim *et al.,* 2012). Several investigations focused on a specific light range or have not detailed the effects of exposure to different light colors on biological and physiological (Rogers *et al.,* 2007). That means there is a need for more work on how light color affects different aspects of embryonic and physiological development, such as embryonic development, embryonic traits, hatchability, chick quality, and gene expression, and how this information could enhance breeding(Mehlhorn & Caspers, 2021). This work hypothesizes that different light colors exposure during critical times of embryonic development may improve

embryo growth. Red, blue, and green lights can promote biological responses such as changes in metabolic rates, gene expression, and tissue growth. Some lab examinations have shown that red light can increase the growth speed of chicken embryos, whereas blue light can affect the nervous system's progress (Rozenboim *et al.,* 2012). The light colors can affect the fetus's hormonal activity. Exposure to light can secrete corticosterone, a vital hormone in growth regulation and stress response for chick embryos (Rozenboim *et al.,* 2004). Light is able to stimulate embryo growth by stimulating of blood flow and metabolism, accelerating tissue growth, and improving embryo growth (Abdulateef *et al.,* 2020). Light can affect embryo metabolic rates by increasing energy consumption and storage differences. This can significantly affect the rate of growth and the efficiency of embryo changes(M. Jiang *et al.,* 2022).

Light controls the embryo's biological clock, influencing growth timing, hormonal activity, and organ development. This regulation contributes to identifying everyday growth habits and preparing for life after hatching (Riaz *et al.,* 2021). Light also affects the production of hormones necessary for embryo growth and development. For example, exposure to specific light colors can increase the production of hormones such as corticosterone, which regulates physiological responses and nervous system development (Zeng *et al.,* 2022). Some studies show that using different colors of light (such as red, blue, and green) can affect embryonic development in different ways. For example, red light may stimulate faster growth than blue or white light. Also, light with a red spectrum can lead to better survival rates and internal organ growth than blue-spectrum light (Gratta *et al.,* 2023). In a study conducted by (Abdulateef, Al-Bayar, *et al.,* 2021)using multiple types of lighting, namely red, green, and blue, if there is a significant increase in embryonic development, an increase in embryo weight, body weight of hatched chicks, hatchability, and embryo index for green light. There was also a significant development in neurophysiological characteristics of neurons, brain index, and brain weight (Chelnokova *et al.,* 2023).

This investigation aims to explore and identify the role that different light colors of light play in influencing the growth and development of the chicken embryo, focusing on the physiological and evolutionary changes caused by this exposure. Several developmental indicators, including weight at hatching, the development of major organs such as the heart and brain, and physiological indicators such as hormone levels and metabolic activity, will measure the effects of these light colors.

MATERIAL AND METHODS

Animal Study

The investigation was performed using the protocol approved by the University of Anbar Ethics Committee, Iraq. Fertile eggs from Ross (308) strain broiler breeder hens were obtained from a commercial farm.

Experimental study

This investigation was performed in animal sciences at the College of Agricultural Sciences and the University of Sulaymaniyah, Iraq, to examine the impact of various light colors on embryonic development, hatchability, and the quality of hatched chicks. Four egg incubators

were utilized (Cimuka). Each of them was utilized for the egg's incubation in a suitable light color. Experimental treatments were as follows: Dark without light (control) (D), Red Light (RL), Blue Light (BL), and Green Light (GL), with three replications; 75 eggs per treatment: (25 egg/replicate), in total 300 eggs fertile of Ross 308, 75 eggs in every incubator (each treatment in the incubator separately, the incubators were similar in all circumstances), eggs were obtained from the local supplier. All environmental conditions, such as temperature, Co2 concentration, humidity, and ventilation, were identical in all incubators.

Light control

This investigation provides 12:12 light: dark through the used electric LED (intensity = 560 nm, 0.1 lux/m2 at eggshell level). The light was supplied from 2-21 incubation days. Incubators were provided in Dark (D), Red Light (RL), Green Light (GL), and Blue Light (BL).

Studied traits

Embryonic test

The first embryonic examination was performed three days after incubation, where the eggs were placed horizontally. The shell was removed, and the subsequent traits were calculated: Vascular region, embryo length, and pairs of somites. The second embryonic examination was performed seven days after incubation. In this test, the eggshell was broken, the egg's contents were taken out, and embryo weight, Albumin, and shell were measured. The third embryonic examination was performed fourteen days after incubation. The eggshell was broken, and the contents of the egg were removed. The subsequent traits were calculated: yolk, amniotic sac, embryo weight, liquid, and Albumin. The fourth embryonic examination was performed within seventeen days of incubation. The eggshell was broken, and the contents of the egg were removed. The subsequent traits were calculated: yolk, embryo weight, and eggshell (Mississippi State University Extension, 2010).

Hatchability, Egg weight, and Chick Quality

The egg weight for the control and experimental groups, ranging from 50-60 g, was almost the same. In eighteen days of hatching, the embryo was extracted, following (Thabit *et al.,* 2023) method, and the embryo was weighed. After hatching, the chicks were collected from the control and experimental groups and weighed on the hatching day. The hatchability was determined as (No. of chicks hatched/No. of fertile eggs set). After hatching, the quality of the chicks, as well as body weight and length for all groups, were measured (Willemsen *et al.,* 2008).

Hormone Concentration

Blood samples were obtained from the jugular vein of three chicks in each replicate before hatching and one day after hatching. After separating the serum from the cellular blood, the blood serum was put in plastic tubes and transported through a cooler box to the Al-Kok Specialized Scientific Laboratory to perform an ELISA examination and measure the concentration of corticosterone utilizing a testing kit. SunLong Biotech Co., LTD made the ELISA test kit, which was utilized according to the instructions in the kit's leaflet (Rettenbacher *et al.,* 2004).

Statistical Analysis

A Complete Randomized Design (C.R.D) was conducted, and the SAS program (System., 2004) was utilized to analyze the data. The means for each treatment were compared utilizing Duncan's polynomial, employing various significance levels to decide meaningful differences among the averages (Duncan, 1955).

RESULTS AND DISCUSSIONS

Table 1. Showed the impact of light colors on embryonic development at three days after incubation if it was found that there was a considerable difference (P≤0.05) in the embryo length (mm) if GL (12.6 mm) outperformed D and the other two treatments RL and BL, while there was a considerable difference (P≤0.05) in the vascular region (mm) if GL excelled (11.4 Mm) on D and the other two treatment RL and BL. There was a considerable difference (P≤0.05) in the number of Pairs of somites if GL (36.6) outperformed D and the other two treatments, RL and BL. Furthermore, there was no considerable difference in the Shell weight trait between the experiment treatment and the control D.

Table 1. The impact of light colors on embryonic development at three days from incubation

Traits	The egg weight at the test %				SEM†	Mean	P-value
	Treatment						
	D	RL	BL	GL			
Embryo Length (Mm)	8.46 b	9.30 b	9.11 b	11.4 a	0.3914	9.57	0.0127
Vascular Region (Mm)	10.4 b	10.7 b	10.6 b	12.6 a	0.3149	11.1	0.0096
No. of Pairs of Somites	32.0 b	33.0 b	33.6 b	36.6 a	0.5751	33.8	0.0018
Shell weight	11.10	11.13	11.16	10.93	0.0757	11.0	N.S.

SEM: Standard Error of the Mean
N.S.: Non-Significant
a, b, c: means in the rows with different significantly at probability values 0.01 and 0.05.
Treatment D = Control (without Light), Treatment RL= Red Light, Treatment BL = Blue Light, and Treatment GL= Green Light.

Table 2. showed the effect of light colors on embryonic development at seven days from incubation if it was found that there is a considerable difference (P≤0.05) in the embryonic weight if GL (2.14 gm) surpassed D and BL and did not differ from RL, while there was a significant difference (P≤0.05) in the amniotic weight + fluid if GL excelled Which amounted to 3.89 gm on the control treatment D and the other two treatment RL and BL. RL also outperformed the control treatment D and BL. There was also a considerable difference (P≤0.05) in the trait of allantoic weight + fluid if GL, which amounted to 6.68 gm, outperformed the control treatment D and the other two transactions are RL and BL, as well as RL outperformed the control treatment D and BL. There was a considerable improvement (P≤0.05) in the albumin weight trait GL (8.53 gm) compared to the control treatment D and the treatments RL and RL improved over the control treatments D and BL. There was no considerable difference in the trait of Yolk weight between the treatments of the experiment and the treatment of the control. As for the shell weight trait, it improved significantly (P≤0.05) if GL improved, which amounted to 8.10 gm in comparison to the

control D and the RL and RL improved on the control treatment D and did not differ from BL, which did not show a different with D.

Table 2. The impact of light colors on embryonic development at seven days from incubation

Traits	The egg weight at the test % Treatments				SEM †	Mean	*P*-value
	D	RL	BL	GL			
Embryonic weight	1.23 b	1.31 b	1.67 ab	2.14 a	0.1262	1.59	0.0099
Amniotic weight	3.14 c	3.23 c	3.46 b	3.89 a	0.0880	3.43	<.0001
Allantoic weight	4.42 c	4.46 c	5.26 b	6.63 a	0.2827	5.19	0.0002
Albumin weight	10.9 a	10.3 a	9.60 b	8.53 c	0.2868	9.86	0.0002
Yolk weight	18.0	18.5	17.3	16.3	0.3633	17.5	N.S. ‡
Shell weight	10.5 a	9.99 ab	9.26 b	8.10 c	0.3018	9.48	0.0011

SEM: Standard Error of the Mean; N.S.: Non-Significant; a, b, c: means in the rows with different significantly at probability values 0.01 and 0.05. Treatment D = Control (without Light), Treatment RL= Red Light, Treatment BL = Blue Light, and Treatment GL= Green Light.

Table 3. The impact of light colors on embryonic development at seven days from incubation shows there is a considerable difference (P≤0.05) in embryonic weight if GL (19.2 gm.) outperformed D, BL, and RL, and RL outperformed D and BL, which did not differ from each other. There was no considerable difference in amniotic weight + fluid among the treatments. There was no considerable difference (P≤0.05) in the allantoic weight + fluid between the treatments. While there was a considerable improvement (P≤0.05) in the albumin weight trait if GL improved (5.24 gm) in comparison to the treatment D and RL and did not differ from BL, which did not differ from D. A considerable advancement was found (P≤0.05) in the yolk weight trait if GL improved, which amounted to (11.5 gm) compared to the control treatment D and RL and did not differ from BL, which did not differ from D. As for the shell weight trait, a considerable improvement (P≤0.05), if GL improved, which amounted to (5.80 gm) compared with the control transaction D and the other two transactions RL as well as BL, outperformed the control treatment D and BL which improved on D and RL.

Table 3. The impact of light colors on embryonic development at 14 days from incubation.

Traits	The egg weight at the test % Treatments				SEM †	Mean	*P*-value
	D	RL	BL	GL			
Embryonic weight	14.5	14.4 c	17.1 b	19.2 a	0.6539	16.3	0.0012
Amniotic weight	11.9	12.2	12.4	13.4	0.2649	12.5	N.S. ‡
Allantoic weight	9.26	10.1	10.0	11.6	0.3969	10.2	N.S. ‡
Albumin weight	7.88	6.96 ab	6.20 bc	5.24 c	0.3189	6.57	0.0014
Yolk weight	15.8	14.2 b	14.8 ab	11.5 c	0.5221	14.1	
Shell weight	8.50	8.40 a	7.00 b	5.80 c	0.3435	7.42	<.0001

SEM: Standard Error of the Mean; N.S.: Non-Significant; a, b, c: means in the rows with different significantly at probability values 0.01 and 0.05. Treatment D = Control (without Light), Treatment RL= Red Light, Treatment BL = Blue Light, and Treatment GL= Green Light.

Table 4 presents the effect of light colors on embryonic development 17 days from incubation. There is a significant difference (P≤0.05) in the embryonic weight trait GL (29.1 gm.) surpassed D, BL, and RL. Also, RL and BL outperformed D, which did not differ from each other. Forever, there was a considerable difference (P≤0.05) in the trait amniotic weight + fluid If GL, which reached 18.3 gm, outperformed D, BL, and RL. There was a considerable difference (P≤0.05) in the allantoic weight + fluid if GL, which amounted to 25.2 gm, outperformed D, BL, and RL, which did not differ from each other. GL improved by 11.1 gm compared to the control treatment D and RL and differed from BL. As for the shell weight trait, it improved significantly (P≤0.05) if GL improved, which amounted to 6.03 gm in comparison to the D treatment. The RL did not differ from BL, which in turn did not differ from RL, which did not show a difference from D. Table 5. The impact of light colors on the hatchability and chick quality is shown: a considerable difference (P≤0.05) in the hatchability (%) if GL (78.2%) surpasses D, BL, and RL; also, BL surpasses D and RL, which did not differ from each other. Furthermore, there was a considerable difference (P≤0.05) in the trait Length (cm) If GL, which amounted to 21.8, outperformed D and BL, and the latter two outperformed D. There was a considerable difference (P≤0.05) in the trait of Weight (gm) if GL, which amounted to 40.5, outperformed D, BL, and RL, and the latter two outperformed D.

Table 4. The impact of light colors on embryonic development at 17 days from incubation.

Traits (gm.)	The egg weight at the test % **Treatments**				**SEM** †	**Mean**	*P*-value
	D	**RL**	**BL**	**GL**			
Embryonic weight	24.1 c	26.0 b	27.5 b	29.1 a	0.5777	26.7	<.0001
Amniotic weight	15.0 b	15.2 b	16.2 b	18.3 a	0.4529	16.2	0.0067
Allantoic weight	20.5 c	22.5 b	23.9 b	25.2 a	0.5402	23.0	<.0001
Yolk weight	17.1 a	15.4 a	12.8 b	11.1 b	0.7625	14.1	0.0021
Shell weight	7.96 a	7.30 ab	6.46 bc	6.03 c	0.2592	6.94	0.0080

SEM: Standard Error of the Mean; N.S.: Non-Significant; a, b, c: means in the rows with different significantly at probability values 0.01 and 0.05. Treatment D = Control (without Light), Treatment RL= Red Light, Treatment BL = Blue Light, and Treatment GL= Green Light.

Table 5. The impact of light colors on the hatchability and chick quality.

Traits	The egg weight at the test % **Treatment**				**SEM**†	**Mean**	**P-value**
	D	**RL**	**BL**	**GL**			
Hatchability (%)	66.3 c	66.7 c	73.5 b	78.2a	1.547	71.2	<.0001
Length (Cm)	16.6 c	19.2 b	20.0 b	21.8 a	0.5859	19.4	<.0001
Weight (gm)	35.4 c	38.4 b	38.9 b	40.5 a	0.5832	38.3	<.0001

SEM: Standard Error of the Mean; N.S.: Non-Significant; a, b, c: means in the rows with different significantly at probability values 0.01 and 0.05. Treatment D = Control (without Light), Treatment RL= Red Light, Treatment BL = Blue Light, and Treatment GL= Green Light.

Figure 1 presents the impact of Light Colors on the hormone corticosterone (ng/100 ml blood) 1 day before and after Hatching. There was a significant improvement in GL, which amounted to 1.3 ng/100 ml blood before hatching compared to the other experimental treatments, and the BL treatment did not differ from RL, which differed from D. As for after hatching, there was a significant improvement in GL, which amounted to 1.01 ng. /100 ml blood. After hatching, compared with the other experimental treatments, treatment BL did not differ from RL, which differed from D.

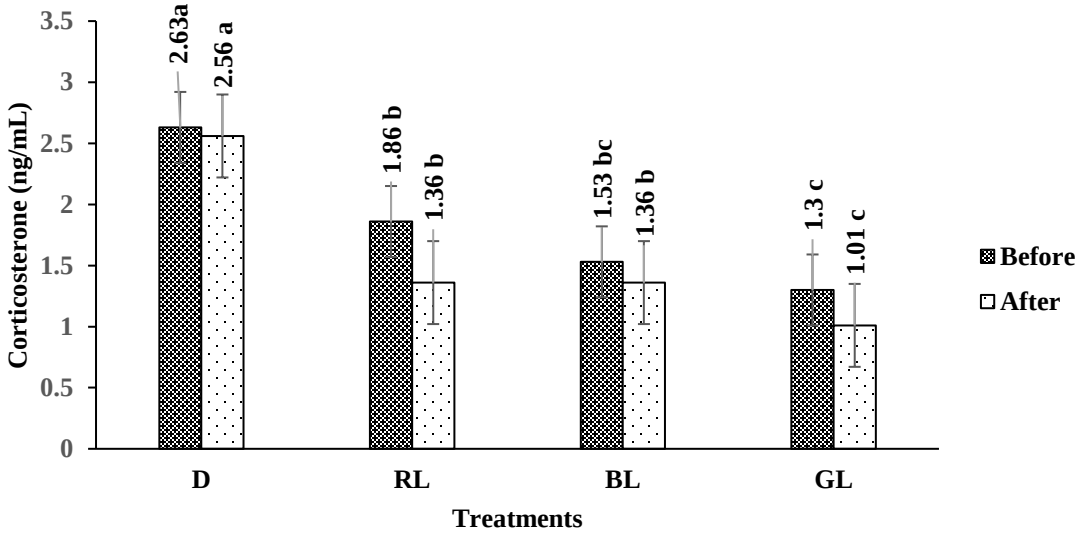

Figure 1. The impact of Light Colors on the hormone corticosterone (ng/100 ml blood) 1 day before and after Hatching

N.S.: Non-Significant
a, b, c: means in the rows with different significantly at probability values 0.01 and 0.05.
Treatment D = Control (without Light), Treatment RL= Red Light, Treatment BL = Blue Light, and Treatment GL= Green Light.

The regulation of the light cycle plays an essential function in the development of chicken embryos within the eggs, as different light cycles directly affect several vital processes related to embryo growth and development. As an environmental factor, light substantially influences the embryo's biological clock regulation, which controls an expansive scope of physiological functions such as embryonic development, sleep-activity cycles, and metabolism. For example, a researcher tried to investigate how light cycles could affect egg embryo development and showed that prolonged lighting can promote embryo growth. The reason for this improvement was to enhance cellular metabolism (Li *et al.,* 2021). A longer light cycle can affect the embryo, where subjecting leads to greater locomotor activity, supporting the physiological processes necessary for hatching (Sindhurakar & Bradley, 2012). The eggs' temperature is also affected by light; temperature affects the growth rate of the embryo. Red (Light Colors) and blue light affect embryo growth; it stimulates the production of hormones, such as thyroid hormone. Thyroid hormone accelerates cellular metabolism and effectively converts food into energy (Adegbenro *et al.,* 2023). As a result, it accelerates the growth of the fetus and significantly improves its weight. Red light activates biological pathways such as the PI3K/Akt pathway, which promotes cell growth and survival and

stimulates the growth of tissues and organs in a healthy, balanced state(Gnocchi *et al.,* 2012) (Dishon *et al.,* 2017).

On the other hand, blue light recreates a vital function in the control of the embryo's biological clock. It directly affects the regulation of melatonin production, controlling sleep-wake cycles and ensuring optimal requirements for rest and activity (Bian *et al.,* 2020). Blue light can enhance the photoreceptor's effectiveness in embryo tissues. Also, it can improve physiological responses to light and maintain embryonic development processes (Chiandetti *et al.,* 2013). Greenlight has a prominent role in embryo development, where it affects the biological clock and allows control of sleep-wake cycles. This regulation can affect neurodevelopment. The green light stimulates cell differentiation and cellular growth, which is essential for developing nerves and surrounding tissues. In other biological models, some light colors directly stimulate the growth of neurons or the formation of neuronal connections (Dishon *et al.,* 2017). Gene expression can be affected by heat within embryonic cells, as some genes are activated and repressed in response to the changes in temperature. Proteins that control nerve growth, muscle building, and organ development can be affected by these changes (Yalcin *et al.,* 2022). Also, it enhances oxygen delivery by improving the blood circulation rate within the egg, which in turn can enhance the delivery of oxygen to the embryo tissues. Cellular respiration, energy production, and efficient removal of metabolic waste depend strongly on oxygen. Levels of growth hormones (GH) can be affected by light and heat, which is essential for the growth and development of embryo (Zouridis *et al.,* 2015). Heat controls hormones such as IGF-1 and growth hormone, which help tissue and bone grow and thus keep the internal environment stable. Therefore, light can maintain the stability of the egg temperature, which protects the embryo from external fast temperature changes that may cause irregular growth (Yalcin *et al.,* 2022).

Light plays a significant function in hormonal control in bird embryos; it influences hormone secretion. For instance, light stimuli stimulate thyroid hormone secretion (T4), which restores organ formation and nervous system development in bird embryos (Yu *et al.,* 2018). Light affects the secretion of stress and food-regulating hormones, affecting the growth and development of bird embryos in embryonic time; it accelerates cellular respiration. The hormone can control how cells use energy and help tissues and organs grow (Özkan *et al.,* 2012). In embryo development, light and dark cycle differences can affect melatonin levels and, as a result, metabolic and sleep cycles. Melatonin is thought to control embryo growth and development, especially in species exposed to light cycles during incubation. Light can influence levels of corticosteroid hormones, modulating physiological responses to stress and enhancing the effectiveness of embryo metabolism (Chiandetti *et al.,* 2013).

On the other hand, light can promote GH production, which is essential for embryo development. This hormone contributes to tissue growth and cell differentiation and regulates the overall metabolism of the embryos (Yu *et al.,* 2018). GH supports and stimulates the muscles, bones, and tissue formation and stimulates the body to utilize fat as an energy source rather than store it. Similarly, GH sustains numerous other metabolic processes, such as breaking down proteins and controlling blood sugar levels (Chelnokova *et al.,* 2023). Light influences the bird's biological system by modifying the biological clock and activating metabolic operations. Light

promotes the pineal gland to secrete melatonin after dusk, which allows birds to fall asleep (N. Jiang *et al.,* 2020). Light interacts with genes during the day, such as CLOCK and BMAL, to control PER2 protein production, reset the biological clock, and control sleep-wake cycles. Light triggers SREBP, a transcription factor that promotes the gene expression associated with cholesterol synthesis, which is essential for hormone production (Ma *et al.,* 2019). This leads to the production of neurosteroid 7-α-hydroxy-pregnenolone, which stimulates locomotor activity and regulates the bird's daily activity. Light can regulate the behavioral and physiological fetus's patterns (Mahmood & Abdulateef, 2021; Shawkat *et al.,* 2023), as a result, enabling them to maintain high activity levels throughout the day and enhancing biological efficiency (Tsutsui *et al.,* 2010).

Lighting through several mechanisms such as thermoregulation could impact bird's hatchability. Red and infrared light increases the egg temperature and enhances cell metabolism and healthy embryo development (Archer, 2018). Also, the embryo's biological clock could be impacted by lighting. It controls growth and activity cycles and guarantees that the embryos develop and can hatch at the right time (Li *et al.,* 2021). Red light promotes cell proliferation and differentiation and as a result, encourages organ and tissue growth and enhances hatchability. The overall health of adult birds is also affected by lighting, where it reduces stress, stimulates healthy hatching behaviors, and enhances egg quality (Abdulateef, Majid, *et al.,* 2021; Al-Bazy *et al.,* 2022). Successful hatching depends on good nutrition and eggshell quality (Boğa Kuru *et al.,* 2023).

CONCLUSIONS

It can be concluding that exposing broiler chicken embryos to different light colors and at all embryonic stages of the embryos may contribute increasing the rate of growth, embryonic development, and hatching. Like increasing the weight of the embryo, which can lead to an increase the hatched chick's weight. Consequently, producing chicks characterized by high weight and quality, which gives a final weight and contributes to increasing the ideal final production when marketing.

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