Tikrit Journal for Agricultural Sciences
ISSN:1813-1646 (Print); 2664-0597 (Online)
Journal Homepage: http://www.tjas.org
E-mail: tjas@tu.edu.iq
DOI: https://doi.org/10.25130/tjas.25.4.16

TJAS
Tikrit Journal for Agricultural Sciences

Comparison of the Effect of Monochromatic Light Types with White Light on the Productive Performance and Testosterone of Ross 308 Male Broilers

Mortadha A. Zwain, and Aqeel Y. A. Al-Shukri
Department of Animal Production, Faculty of Agriculture, University of Kufa, Najaf, Iraq
.
***Correspondence:** **mortadhaa.zwain@student.uokufa.edu.iq**

KEY WORDS:
Monochromatic light, Productive characteristics, Poultry, testosterone

Received: 01/05/2025
Revision: 05/08/2025
Proofreading: 22/10/2025
Accepted: 08/09/2025
Available online: 31/12/2025

ABSTRACT

The study was carried out from September 22 to October 27, 2024, in the poultry field at the Department of Animal Production, College of Agriculture / University of Kufa. The study aimed to investigate the effects of monochromatic light on broilers (Ross 308) and their productive characteristics. 180 one-day-old male Ross308 crossbred broiler chicks, were used. Each chick weighed an average of 42.5 grams. The chicks were fed three different diets: From one to ten days of age they were fed a starter diet, from eleven to twenty-four days, they were fed a grower diet; and from twenty-five to thirty-five days, they were fed a finisher diet. The three diets' respective energy contents were determined to be 2975, 3050, and 3100 kcal/kg. In that order, the protein content was also determined to be 23, 21.50, and 20.08 %. By employing a random distribution method, the one-day-old chicks were divided into four treatments. Each treatment consisted of 45 chicks, with three replicates. Each duplicate had 15 males. The treatments that were given were T1 (control, white light), T2 (blue light), T3 (red light), and T4 (green light).The study's findings revealed a statistically significant increase ($P \leq 0.05$) in the ultimate live body weight, total feed consumption, testosterone, and overall weight increase(day 35) of the avian subjects in the T2 (blue light) in comparison to the control group, T1 and the other groups. The feed conversion ratio for the birds experienced a substantial enhancement.

مقارنة تأثير أنواع من الضوء الأحادي اللون مع الضوء الأبيض على الأداء الإنتاجي و هرمون التستوستيرون لذكور هجين فروج اللحم روز 308

مرتضى زوين ، عقيل الشكري
قسم الانتاج الحيواني، كلية الزراعة-جامعة الكوفة، العراق

الخلاصة

أجريت الدراسة خلال الفترة من 22 سبتمبر إلى 27 أكتوبر 2024 في حقل الدواجن بقسم الإنتاج الحيواني في كلية الزراعة / جامعة الكوفة. هدفت الدراسة إلى معرفة تأثير الضوء أحادي اللون على الصفات الانتاجية لذكور فروج اللحم (روز 308) . تم استخدام 180 فرخًا من ذكور فروج اللحم الهجين روز 308، بعمر يوم واحد. بلغ متوسط وزن كل فرخ 42.5 جرامًا. تم تغذية الكتاكيت على ثلاث علائق مختلفة؛ من عمر يوم إلى عشرة أيام (عليقة بادئ) ، ومن أحد عشر إلى أربعة وعشرين يومًا(عليقة نمو) ، ومن خمسة وعشرين إلى خمسة وثلاثين يومًا، (عليقة نهائي). تم تحديد محتوى الطاقة في العلائق الثلاثة ليكون 2975 و 3050 و 3100 كيلو كالوري / كجم. على التوالي كما تم تحديد محتوى البروتين ليكون 23 و 21.50 و 20.08٪ على التوالي. باستخدام التوزيع العشوائي، تم تقسيم الافراخ بعمر يوم واحد إلى أربع معاملات. تتكون كل معاملة من 45 فرخ ، مع ثلاث مكررات. كان لكل مكرر 15 ذكرًا. المعاملات التي أعطيت هي T 1 (معاملة السيطرة ، الضوء الأبيض)، T 2 (الضوء الأزرق)، T 3 (الضوء الأحمر)، T 4 (الضوء الأخضر). كشفت نتائج الدراسة عن ارتفاع ذي دلالة إحصائية ($P \leq 0.05$) في الوزن الحي النهائي للجسم وإجمالي استهلاك العلف وزيادة الوزن الكلية للطيور و مستوى هرمون التستوستيرون عند عمر 35 يوم في المجموعة 2T (الضوء الأزرق) مقارنة بمعاملة السيطرة 1T والمعاملات الأخرى. كما شهد معامل التحويل الغذائي لمعاملة اللون الازرق تحسنًا ملحوظا.

الكلمات المفتاحية: الضوء أحادي اللون، الخصائص الإنتاجية ، فروج اللحم، هرمون التستوستيرون.

INTRODUCTION

Rising competition and energy costs in the poultry sector are the major contributing factors making producers look for lower production costs. To ensure economic viability, management efforts must be directed towards enhancing poultry welfare and performance in an integrated and synchronous manner. Concerns about the quality of the product and the conditions in which the poultry is bred have recently increased among producers and consumers (Harper G, 2001).

Avian vision is highly dependent on light conditions, affecting their ability to distinguish colors and visual acuity (Calvet S, 2009). Furthermore, a minimum illumination of 20 lux is required for the lighting system in a chicken house to facilitate easy vision and thorough inspection (rspca, 2013). Human and domestic fowl are distinguished in spectral sensitivity, significantly impacting broiler chickens' well-being, behavior, and productivity. They have great sensitivity to ultraviolet, blue, green, and red light spectra (Prescot NB, 1999). This sensitivity is mediated mainly through their retinal and deep brain photoreceptors (Kuenzel WJ, 2015). Additionally, they have three evolved light-sensitive receptors in the brain that substantially affect their biological and physiological functions (Retinal Photoreceptors (in the eyes) , Pineal Gland Photoreceptors and Deep Brain Photoreceptors or Encephalic Photoreceptors) (Bertolucci C, 2004) and (Wyse C, 2009). Producers can manipulate and control variables such as temperature, humidity, ventilation, gases, intrusion and effusion intensity, duration, and light color to increase revenue. Light being involved in many physiological and behavioral processes is the most significant of the factors described above (Olanrewaju HA, 2006). Light has three main components: spectral content, color, and photoperiod (duration) (Olanrewaju HA, 2006). (Anja, 2015) Explains that different inputs from different visible spectrum wave types estimate the light wavelengths. Turning on a few lights could affect poultry performance (Jin E, 2011). Reddish-orange light promoted reproduction, while green light increased growth rate (Rozenboim I, 2004). Exposure to green light encourages young birds to grow, and old birds are stimulated by blue light (Classen HL, 2004). (Levenick, 1988) observed that female and male turkeys grew significantly under blue light (BL) until 16 weeks. A new light source, such as an LED lamp, was added to determine

the role of monochromatic light in broiler growth and performance and to clarify the relevant mechanisms in this study. Artificial illumination, defined as manipulating either or all of light duration, color and intensity, is now widely used to increase broiler performance using a single light source.

The introduction of inexpensive and energy-efficient monochromatic light sources like LED lamps may enhance broiler production, which would be of considerable value for the broiler farmer whilst at the same time reducing electricity use.

MATERIAL AND METHODS

The study was carried out from September 22 to October 27, 2024, in the poultry field at the Department of Animal Production, College of Agriculture, and University of Kufa. The study aimed to investigate monochromatic light's effects on broilers' productive characteristics. On average, 180 one-day-old Ross 308 crossbred male broiler chicks were used; Average Weight of chicks was 42.5 g. twelve cages (each 3 m^2 in surface area) were used.

Chicks were provided ad libitum access to feed and water; the chicks were fed three different diets as follows:- From 1 to 10 days of age, they were fed a starter diet- From 11 to 24 days of age, they were fed a grower diet- From 25 to 35 days of age, they were fed a finisher diet The corresponding energy contents of the three diets were 2975, 3050, and 3100 kcal/kg, respectively. The protein percentage was determined as 23%, 21.50%, and 20.08%, respectively. The one-day-old chicks were divided into four treatments using a random distribution technique. The experiment consisted of four treatments, each of which included three replicates of 15 males. The applied treatments were:

- T1 (control, white light) - T2 (blue light) - T3 (red light) - T4 (green light)

The room temperature was maintained at 3 4the first week and then reduced C for° daily until it ,reached 24°C which was maintained until the end of the experiment. From the first day, all broilers were exposed to either Blue (480nm), Green (560 nm), Red (660 nm), or White (400 to 700 nm), using monochromatic LED lamps until the end of the experiment. All light sources were equalized to 40 Lux for the first week, then reduced to 10 Lux from week 2 till the end of the experiment at the head level of birds on a light schedule of 23 h light 1h dark (23L:1D).

Measurement of Productive Performance

The electronic scale was used to record body weights (g) on days 1,7,14,21,28, and 35 at 08:00 h. In addition, the weekly feed consumption (g) of each pen was recorded at 08:00 h, and the feed conversion ratio of each pen was calculated

[feed conversion ratio = feed consumption (g)/ net Body Weight gain (g)].

Birds were exsanguinated, plucked, and eviscerated (carcass devoid of head, shank, viscera, and abdominal fat). The conditions on the slaughter line were non-stressful. After the experiment, the eviscerated carcass and the breast, thigh, back, wing, and neck were weighed (Cao J. W., 2012) (Table 6)

Table 1. The experiment used components of the starter, growth, and final diets.

Feed ingredients used	Starter diet 1-10 day	Grower diet 11-24 day	finisher diet 25-35 day
yellow corn	50.50	54.00	58.00
Soybean 48%	36.00	32.00	27.50
Crushed wheat	8.00	8.00	7.00
Premix*	2.50	2.50	2.50
Corn oil	1.50	2.00	3.50
Dicalcium phosphate**	0.1	0.1	0.1
Limestone	1.1	1.1	1.1
Salt	0.3	0.3	0.3
Total	100	100	100
Chemical composition			
Energy (Kcal/Kg)	2975	3050	3100
Crude protein%	23	21.50	20.08
Total calcium%	1.102	1.09	1.08
Available phosphorus%	0.74	0.72	0.71
Energy/crude protein ratio	129.34	141.86	154.38

*Commercial protein concentrate was used with ready energy content estimated at 4900-kilo calories/kg, crude protein 18%, fat 1.1%, calcium 15-19%, lysine 9.4%, phosphorus 6.8%, sodium 4.8%, chlorine 5.8%, methionine 7.8%. Methionine + cysteine 7.8%, threonine 0.55%, a mixture of vitamins and rare minerals to meet the bird's needs.** Dicalcium phosphate contains 22% inorganic calcium and 8% inorganic phosphorus. Chemical composition was calculated according to Ross company instructions (ross, 2022).

Measurement of testosterone

Blood samples were collected from the brachial vein at 0800 h on days 21 and 35. The testosterone level in the plasma was determined using chicken testosterone ELISA kit CAS: ADL-EL-CK00048 (Shanghai Ideal Medical Technology Co., Ltd) (Table 7).

Experimental design and Statistical analysis

Experimental treatments were assigned in a completely randomized design (CRD), and the experimental data were statistically analyzed using the SAS 2012 program (sas, 2012). The means of the treatments were compared at a level of significance ($P \leq 0.05$) using Duncan's Multiple Range Test (1955) (Duncan, 1955)

RESULTS AND DISCUSSION

The effects of monochromatic light on broilers' BW (body weight) are shown in Table 2. When the broilers were reared under single monochromatic lights, observed larger BW of birds under blue light (T2) and red light (T3) than the BW under white light (T1) and green light (T4) in week 1 . Week 2 we noticed a significant increase in (T2) compared to (T4) , week 3 there were significant increase in treatments (T1,T2,T3) compared to (T4) . In week (4,5) we noticed a significant increase in BW of (T2) blue light compared to the control and other treatments

Table2. The effect of monochromatic light on the body weight of broilers Ross308.

Treat	Age					
	Day 1	Week 1	Week 2	Week 3	Week 4	Week 5
T1 (WL)	42.5±0.14	166.6±2.71b	459.8±12.46ab	915.1±27.22 a	1482 ±44.16 b	2228.6 ±35.61 b
T2 (BL)	42.4±0.04	182.6±3.29a	478.7±6.94 a	906.6±4.71 a	1565 ±6.94 a	2359 ±15.92 a
T3 (RL)	42.7±0.09	183.5±2.05a	462.8±2.71 ab	889.3±18.78 a	1515.5 ±30.44 b	2250.6 ±47.31 b
T4 (GL)	42.6±0.23	167.4±0.31b	440±6.81 b	829.7±13.05b	1409.7 ±23.09 c	2169.4 ±21.58 b
Significance	N.S	*	*	*	*	*

*Means followed by different letters within a column are significantly different according to Duncan's multiple range tests (P≤0.05), where NS indicated no significance. Treatments are: T1 white light (control), T2 blue light, T3 red light, and T4 green light.

Table 3 demonstrates the effects of monochromatic light on the weight gain of broilers. Week 1 the weight gain of birds raised under (T2, T3) was significantly greater than that of birds raised under (T1, T4) . Week 2 there was no significant differences. Week 3 (T1) is significantly higher than (T4) while there is no difference between (T1, T2,T3) . In week 4 there is a significant increase in WG of (T2) compared to (T1 and T4), while in week 5 there is a significant increase in WG of blue light treatment (T2) compared to all treatments. In cumulative (T2) is significantly better than control and other treatments.

Table 4 shows how broiler feed consumption is affected by monochromatic light. A single monochromatic light source was used to raise the broilers. This study shows a significantly increased feed consumption for birds reared under (T2 and T3) compared to (T1 and T4) in the first week, while second week shows a significant increase for (T2) compared to (T4) . Week 3 the treatments (T1 ,T2 and T3) are significantly higher than (T4) . In week 4 (T2) is significantly higher than (T1 and T4) , and (T3) is significantly higher than (T4) . Week 5 there was no significant differences. In cumulative (T2) is significantly higher than control and other treatments.

Table3. The effect of monochromatic light on the body weight gain of Ross 308 broilers

Treat	Age					
	Week 1	Week 2	Week 3	Week 4	Week 5	Cumulative
T1 (WL)	124.1±2.65b	293.2±13.16	455.3±14.85a	566.5±17.69c	747±17.72 b	2186.1±50.56b
T2 (BL)	140.2±3.27a	296±9.19	427.9±2.87ab	658.4±3.70a	794±13.82 a	2316.1±22.45a
T3 (RL)	140.8±2.11a	279.3±1.24	426.5±17.50ab	626±12.19ab	735.3±18.22b	2207.9±67.03b
T4 (GL)	124.8±0.53b	272.6±7.03	389.7±15.49 b	579.6±20.87bc	760±20.15 b	2126.7±32.34b
Significance	*	N.S	*	*	*	*

*Means followed by different letters within a column are significantly different according to Duncan's multiple range tests (P≤0.05), where NS indicated no significance. Treatments are: T1 white light (control), T2 blue light, T3 red light, and T4 green light.

Table4. The effect of monochromatic light on the feed consumption of broilers Ross 308

Treat	Age					
	Week 1	Week 2	Week 3	Week 4	Week 5	Cumulative
T1 (WL)	124.4±3.28b	344.2±10.28ab	572±19.36a	781±27.39 bc	1099.2±13.99	2920.8±65.56b
T2 (BL)	136.6±3.09a	349.3±3.53 a	572.6±8.52 a	871.2±7.53 a	1117.7±44.70	3047.3±43.90 a
T3 (RL)	139.9±1.08a	340.2±6.71 ab	556.6±7.93 a	826.4±14.24ab	1098.6±8.04	2961.7±30.03b
T4 (GL)	123±1.24 b	324.2±4.90 b	518.2±7.34 b	758.6±19.43 c	1072.5±5.16	2796.5±36.50 c
Significance	*	*	*	*	N.S	*

*Means followed by different letters within a column are significantly different according to Duncan's multiple range tests (P≤0.05), where NS indicated no significance. Treatments are: T1 white light (control), T2 blue light, T3 red light, and T4 green light.

There were no significant differences in feed conversion ratios in weeks 1, 2, 3 and 5, as well as in the cumulative period. In week 4 there is a significant decrease in (T1) compared to other treatments However, notice a slight improvement (not significantly) in birds reared under blue light (T2) and green light (T4) in weeks (4,5 and cumulative) compared to birds reared under red light (T3) and white light (T1 control).

The statistical analysis did not show significant differences in the carcass, still an improvement in the size of the breast area was noticed in the blue light treatment (T2) compared to the other treatments. Moreover, an improvement in the size of the thigh area in the green light treatment (T4) was noticed, which was higher than other treatments.

Table5. The effect of monochromatic light on the feed conversion ratio of broilers Ross 308

Treat	Age					
	Week 1	Week 2	Week 3	Week 4	Week 5	Cumulative
T1 (WL)	1.002±0.02	1.173±0.01	1.256±0.002	1.378±0.01a	1.471±0.03	1.336±0.009
T2 (BL)	0.974±0.01	1.180±0.02	1.338±0.02	1.321 b±0.01	1.403±0.03	1.313±0.01
T3 (RL)	0.993±0.01	1.218±0.01	1.305±0.03	1.320±0.01 b	1.494±0.02	1.341±0.02
T4 (GL)	0.985±0.006	1.189±0.01	1.329±0.03	1.308±0.01 b	1.411±0.03	1.314±0.01
Significance	N.S	N.S	N.S	*	N.S	N.S

*Means followed by different letters within a column are significantly different according to Duncan's multiple range tests (P≤0.05), where NS indicated no significance. Treatments are: T1 white light (control), T2 blue light, T3 red light, and T4 green light.

Table6. The effect of monochromatic light on the carcass of broilers Ross 308

Treat	breast %	thigh%	back%	wing%	neck%
T1 (WL)	37.4±0.32	27.2±0.84	17.16±1.04	10.6±0.38	4.76±0.03
T2 (BL)	38.1±0.83	28.1±1.19	16.8±1.06	10.4±0.23	4.7±0.30
T3 (RL)	36.4±0.36	27.8±0.69	19.3±0.70	9.9±0.15	4.28±0.31
T4 (GL)	34.56±2.26	29.46±0.96	19.2±0.79	9.9±0.51	4.26±0.39
Significance	N.S	N.S	N.S	N.S	N.S

*Means followed by different letters within a column are significantly different according to Duncan's multiple range tests (P≤0.05), where NS indicated no significance. Treatments are: T1 white light (control), T2 blue light, T3 red light, and T4 green light.

The amount of testosterone in the plasma was measured using chicken testosterone Elisa kit CAS: ADL-EL-CK00048 (table 7), which shows a significant difference in plasma testosterone level between treatments. BL (T2) was significantly higher than the other treatments while (T1,T3) were significantly higher than (T4) at 35 days.

Table7. The effect of monochromatic light on the testosterone level of broilers Ross 308

Age/treat	**T1(WL)**	**T2(BL)**	**T3(RL)**	**T4(GL)**	**Significance**
21 day	7.17±0.99	7.69±1.64	9.66±1.18	5.22±1.85	N.S
35 day	8.11±0.33b	10.28±0.35a	8.46±1.35b	6.63±0.36c	*

*Means followed by different letters within a column are significantly different according to Duncan's multiple range tests (P≤0.05), where NS indicated no significance. Treatments are: T1 white light (control), T2 blue light, T3 red light, and T4 green light.

The chicken eye can perceive a broader part of the light spectrum than mammalian eyes. The light environment affected the growth and development of broilers, especially the color (wavelength) of light. In the present study, blue light promoted growth, especially in the later stages, corroborating the results of a previous study (Cao J. W., 2008). The current study reported that growth and productive performance were better when broilers were reared under blue monochromatic light. A similar finding was also reported in Anak (Rozenboim I, 2004)and Ross broilers (Karakaya, 2009). Previous studies have reported that heat stress and environmental factors were important in final production performance (AL_ Hatchami & ALshukri, 2023). Compared to broilers raised under red light, those raised under blue light showed superior growth and productivity. This phenomenon may be explained by blue light strengthening the immune system and reducing the stress response in broilers (Xie D. Z., 2008). Conversely, (Ke, 2011)found that blue light may improve meat quality more than red light by reducing oxidative stress. Second, it could have something to do with how blue light affects the epithelium of the small intestine. (Xie D. J., 2011) Found that blue light was more effective than red light at promoting the growth of intestinal villi. Our results, which showed a lower feed conversion ratio in blue light, support this theory. Third, it might have to do with the hypothalamus's stimulation of testosterone secretion and promotion of myofiber growth in blue light as opposed to red and white light (Cao J. W., 2008), (Mobarkey, 2010), and (Rierson, 2011) . However, more study is required to determine how various combinations of

monochromatic lights impact hormone secretions regulated by the hypothalamus. According to some studies, photoperiod did not affect the plasma testosterone levels in turkeys (Škrbić Z, 2012), but it did impact broiler levels (Serra, 2012). Also, the plasma testosterone level of broilers raised was measured by the T Elisa kit under different monochromatic lighting conditions. According to the results, monochromatic light may impact testosterone secretion (Table 7). RL had higher plasma testosterone concentrations in the early stages than other treatments, but no significant difference was observed. In BL, the testosterone level was significantly higher than the other treatments in the later stages (35 days). According to reports, hormones, neuronal innervation, and other growth factors all influence muscle growth. Numerous studies have shown that testosterone is crucial for maintaining muscle mass and force (Rierson, 2011) and controlling muscle growth (Xie D. Z., 2008)– (Xie D. J., 2011). Our findings in broilers raised under different monochromatic lights showed that variations in testosterone levels corresponded with increases in body weight.

CONCLUSION

The current study shows that male broilers (Ross 308) raised in blue monochromatic light grew and developed more effectively when the illumination level was 10 Lux. Weight gain, body weight, and feed conversion ratio were higher in broilers raised under blue light. Thus, it is possible to effectively use blue monochromatic light to enhance broiler growth and productive performance, because blue monochromatic lights stimulated testosterone secretion more effectively, they encouraged muscle growth.

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscrip

ACKNOWLEDGMENTS

The authors gratefully acknowledge the staff of the animal production University of Kufa for their technical and general support.

REFERENCES

AL_ Hatchami, A., & ALshukri, A. (2023). Effect of Diet Fortified with Okra Powder on Blood Quality in Broiler Chickens Under Heat Stress Conditions. *Earth and environmental science*, 1262(7) ,072060.

anja, b. (2015). Effects of color of light on preferences, performance, and welfare in broilers. *Poult Sci*, 94: 1767-1775.

Bertolucci C, F. A. (2004). Extraocular photoreception and circadian entrainment in nonmammalian vertebrates. *Chronobiol Int*, 21: 501-519.

Calvet S, V. d. (2009). The influence of the lighting program on broiler activity and dust production. *Poult Sci*, 88: 2504-2511.

Cao, J. W. (2008). Green and blue monochromatic lights promote growth and development of broilers via stimulating testosterone secretion and myofiber growth. *Poult. Res*, 17:211–218.

Cao, J. W. (2012). Effect of combinations of monochromatic lights on growth and productive performance of broilers. *Poultry Science*, 91(12), 3013–3018. doi:https://doi.org/10.3382/ps.2012-02413

Classen HL, A. C.-l. (2004). The effects of lighting programmes with twelve hours of darkness per day provided in one, six or twelve hour intervals on the productivity and health of broiler chickens. *British Poult Sci* , 45:s31-s32.

Duncan, D. B. (1955). Multiple range and multiple test. *Biometrics*, 11:1-42 .

Harper G, H. S. (2001). Consumer concerns about animal welfare and the impact on food choice. *The University of Reading, United Kingdom.*

Jin E, J. I. (2011). Effect of monochromatic light on melatonin secretion and arylalkylamine N-acetyltransferase mRNA expression in the retina and pineal gland of broilers . *The anatomical record* , 294:1233-1241. .

Karakaya, M. S. (2009). Growth performance and quality properties of meat from broiler chickens reared under different monochromatic light sources. *Br. Poult. Sci*, 50:76–82.

Ke, Y. Y. (2011). Effects of monochromatic light on quality properties and antioxidation of meat in broilers. *Poult. Sci*, 90:2632–2637.

Kuenzel WJ, K. S. (2015). Exploring avian deep-brain photoreceptors and their role in activating the neuroendocrine regulation of gonadal development. *Poult Sci* , 94:786-798.

Levenick, C. K. (1988). Effects of photoperiod and filtered light on growth, reproduction, and mating behavior of turkeys. 1. Growth performance of two lines of males and females. *Poult. Sci*, 67:1505–1513.

Mobarkey, N. N. (2010). The role of retinal and extra-retinal photostimulation in reproductive activity in broiler breeder hens. *Domest. Anim. Endocrinol*, 38:235–243.

Olanrewaju HA, T. J. (2006). A Review of Lighting Programs for Broiler Production. *International Poult Sci*, 5:301-308.

Prescot NB, W. C. (1999). Spectral sensitivity of the domestic fowl (Gallus g. Domesticus). *British Poult sci*, 40:332-339.

Rierson, R. D. (2011). Broiler preference for light color and feed form, and the effect of light on growth and performance of broiler chicks (Doctoral dissertation. *Kansas State University*.

Ross, S. N. (2022). *Ross Nutrition Specification*. Retrieved from https://en.aviagen.com/assets/Tech_Center/Ross_Broiler/RossBroilerNutritionSpecifications2022-EN.p

Rozenboim I, B. I. (2004). The effect of a green and blue monochromatic light combination on broiler growth and development. *Poult Sci*, 83:842-845.

rspca. (2013). RSPCA welfare standards for chickens.

sas. (2012). User's Guide: Statistics, Release Edition. *SAS institute Inc.Cary,NC.*

Serra, C. F. (2012). Testosterone improves the regeneration of old and young mouse skeletal muscle. *J. Gerontol. A Biol. Sci. Med. Sci*. doi:http://dx.doi.org/http://dx.doi. org/10.1093/gerona/gls083.

Škrbić Z, P. Z. (2012). The effect of lighting program and type of litter on production and carcass performance of two broiler genotypes. *Biotechnology in Animal Husband* , 28:807-816.

Wyse C, H. D. (2009). Seasonal biology: Avian photoreception goes deep. *Curr Biol*, 19:R685-R687.

Xie, D. J. (2011). Effect of monochromatic light on mucosal mechanical and immunological barriers in the small intestine of broilers. *Poult. Sci.*, 90:2697–2704.

Xie, D. Z. (2008). Effect of monochromatic light on immune response of broilers. *Poult. Sci.*, 87:1535–1539.