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ALTERNATIVE LIGHT TECHNOLOGY EFFECT ON PRODUCTIVE PERFORMANCE, CARCASS CHARACTERISTICS AND BLOOD PARAMETERS OF BROILER CHICKENS

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SUMMARY

Lighting is an important aspect of the poultry environment. Finding alternative light sources has become important because of the removal of incandescent lights from the market and reduce production costs. This study evaluates the effect of different lighting sources on the productive performance, carcass measurements, and blood parameters of broilers. For this purpose, 200-day-old broiler chicks (Ross 308) obtained from a commercial hatchery were randomly divided into four experimental groups each comprising of 50 birds. The first group was given incandescent light (INC) as a control, the second group was given compact fluorescent light (CFL), the third group was given light-emitting diode white worm light (LEDW), the fourth group was given light-emitting diode white worm cold light (LEDC). Body weight gain, feed intake, and feed conversion ratio were recorded. Carcass, breast muscles, leg muscles, edible parts, and inedible parts as a percentage to live body weight was calculated. Blood collected via the left jugular vein was performed to obtain heterophil to lymphocyte (H: L) ratio and corticosterone concentration. Some blood constitutes were estimated such protein and lipid profiles, Calcium and Phosphorus electrolytes. Some related growth hormones were estimated in blood. Main results showed that using LED bulbs can increase live body weight and it also improved feed conversion ratio of the birds, while there are no significant differences between groups for carcass measurements. Also, the use of LED lights reduces the H/L ratio and the level of corticosterone in the blood, which indicates a decrease in the stress on the birds. The conclusion refers to using LEDC technology as alternative for INC and FL bulbs in broiler houses, as it improves FCR, carcass% and total breast muscle% and achieved resistance to stress when recorded lowest values of blood corticosterone and H/L ratio. The best performance of kidney and liver functions was noticed in LEDC treatment. The LEDC treatment had the highest GH levels in blood.

***Keywords:** Light technology, growth, carcass, blood and broiler*

INTRODUCTION

Several factors affect poultry production, especially with the great development in the productive characteristics of broiler strains (body weight and conversion ratio).

One of the most important of these factors is lighting source, intensity, color, and duration of light. This study was conducted to clarify the effect of the light source on the productive efficiency of broiler chickens. Poultry depends on its behavior and on vision because they have different visual systems than other animals (Mendes *et al.*, 2013). Artificial lighting plays an important role in poultry farms for the bird to reach the best consumption of feed and water, which improves economic feasibility (Mendes *et al.*, 2010). The increasing demand for animal protein that led to power consumption increased which higher production costs (Yanagi, *et al.*, 2011; Pereira *et al.*, 2012), forcing researchers to find light sources with less energy consumption.

Incandescent lamps, which were previously used in broiler farms, depended on converting about 5% of the electrical energy used into light, and about 95% was wasted in the form of heat (Matsumoto and Tomita, 2010; Minaev *et al*., 2014). Therefore, alternative technologies are used to save wasted energy, which are fluorescent and LED lamps. LEDs are solid-state semiconductor devices that emit light in response to an applied voltage (Minaev *et al*., 2014). Consequently, it is considered the ideal light program gives the greatest production and lessens energy costs. Several studies have shown that the use of LED bulbs in broiler chickens' production has high luminous efficiency, lower energy consumption and longer service life compared to incandescent and fluorescent lamps (Cao *et al.,* 2012). Also, fluorescent lamps are more productive and have a more extended working life than incandescent lights but are more limited-lived and less effective than LEDs (Prescott and Wathes, 1999). To choose an ideal light source for birds, it must have an ability to improve physiological and productive performance while enhancing stress resistance and decreasing birds' behavior (Archer, 2015).

Several studies have shown that the use of LED bulbs has led to an improvement in weight gain and an enhancement of the feed conversion ratio, which is reflected in production and economic efficiency (Huth and Archer, 2015).

MATERIALS AND METHODS

Animals and husbandry:

This experiment was carried out at Poultry Breeding Farm, Poultry Production Department, Faculty of Agriculture, Ain Shams University. The present study was conducted to observe the impact of some lighting sources on productive and physiological performance of broiler chickens. The tested lamps were Incandescent (INC), Compact Fluorescent (CFL) and two types of Light-Emitting Diode (LED) lamps referred to as white Worm lamp (LEDW) and white Cold lamp (LEDC). A total of two hundred 1-d old broiler chicks (Ross 308) obtained from a commercial hatchery were used in this study. Chicks were randomly divided into 4 experimental groups, comprising 50 chicks each, designated as replicates. The Incandescent bulb served as the control and was given to birds of group 1(G1), Compact Fluorescent lamp to group 2 (G2), LEDW to group 3 (G3) and LEDC to group 4 (G4). The birds were given 20 lux of light as measured at chick head level using a digital illuminometer (DIGITAL. LIGHT METER YF-172, USA) twice weekly.

From the first day of age, chicks were housed on a deep litter of wood shavings in an experimental poultry house with controlled heating, hygienic and feeding patterns according to standard management requirements for broilers. Birds were fed with a starter diet from 1 to 21 d of age (23% crude protein, 3000 kcal ME/kg), a grower diet from 22 to 28 d of age (21% crude protein, 3200 kcal ME/kg,), and a finisher diet from 28 to 35 d of age (19% crude protein, 3250 kcal ME/kg). Feed and water were available ad-libitum during the experiment.

Productive performance

The birds in each treatment were weighed weekly and body weight gain (BWG) was calculated by the difference between one-day weight and 35-day weight. Feed was weighed weekly for each treatment. Cumulative feed intake (FI) was calculated by subtracting the remaining feed weights in the feeders from the initial feed-added weights. Cumulative FI was recorded by collecting weekly feed consumption. Feed conversion ratio (FCR) was calculated by dividing FI by BWG.

Carcass characteristics:

At 35 days of age, five healthy broiler birds from each treatment were slaughtered for carcass evaluation. The birds were slaughtered by halal methods, feathers, head, shanks, and giblets were removed to calculate carcass yield. Various cut-up parts were also recorded and expressed as a percent of dressed weight.

Blood measurements:

A total of 20 blood samples (4 samples per each treatment) were collected at 35 day of age from the slaughtered chickens during their exsanguinations into heparinized vacuumed tubes. Plasma samples were harvested after centrifugation of blood samples at 6000 rpm for 10 min using laboratory Centrifuge. The plasma samples were stoppered tightly and stored in a deep freezer at -20ºC until blood biochemistry and hormonal analysis were done.

The Heterophils to lymphocytes (H/L) ratio was determined according to (Gross and Siegel, 1983). Plasma total proteins (g/dl) were determined according to the method described by Henry (1974). The determination of plasma albumin (g/dl) based on a colorimetric method was conducted as described by Doumas *et al.* (1971). Globulin was calculated by subtraction of plasma albumin from total plasma protein. Total cholesterol (mg/dl) and high-density lipoprotein (mg/dl) were determined according to the method of Watson (1960). Low density lipoprotein was calculated by subtracting HDL from Total Cholesterol. Triglycerides (mg/dl) were determined by the method of Stein and Myers (1995). The plasma electrolyte calcium (Ca), phosphorus (P) concentrations were measured with a commercial biochemical kit.

The activities of AST and ALT enzymes (U/L) were calorimetrically measured using commercial kits purchased from Spectrum diagnostics and determined according to Reitman and Frankel (1957). The blood concentrations of creatinine and uric acid have been commonly applied as indicators of health status of the kidney (Huang *et al.*, 2017). The radioimmunoassay (RIA) method was used for the determination of plasma triiodothyronine (T_3), thyroxine (T_4) and growth hormone (GH) using commercial kits as reported by (Britton *et al*., 1975).

Statistical analysis:

The obtained data were statistically analyzed by one-way analysis of variance using the General Linear Model (GLM) procedure of SAS 9.0 software (SAS Institute Inc., Cary, NC, USA, 2004).

RESULTS AND DISCUSSION

Productive performance:

The research aims to study the effect of the light source on the productive performance of broiler chickens. The results in (Table 1) showed a significant improvement in live body weight and body weight gain at the age of 35 days in LEDW and LEDC groups (2164 and 2150g) compared to INC and CFL groups (2143g and 2095g). Despite that, there was a significant difference between the experimental groups in the feed intake, as the CFL group (3550 g) was higher in feed intake compared to LEDC, LEDW and IN groups (3544, 3527 and 3522 g respectively). The light source also had a noticeable effect on the feed conversion ratio, as it enhanced the feed conversion ratio in LEDC, LEDW and INC groups compared to the FL groups (1.637, 1.641, 1.644 and 1.694 respectively), indicating that the LEDC and LEDW bulbs resulted in better performance (Body weight gain and feed conversion ratio). This result agrees with (Rogers *et al*., 2015) who observed an increased growth in broiler chickens raised under LED or INC groups when compared to the CFL group. Also, (Olanrewaju *et al*., 2015) observed a body weight gain improvement in LED bulbs than INC bulbs. Likewise, (Huth and Archer, 2015), observed enhance feed conversion in two different LED bulbs over CFL bulbs. And this does not agree with what (Archer, 2015) previously observed. (Archer, 2015) observed that there was no difference in growth or feed conversion between either LED or the CFL treatment. While the bird exposed to LED bulbs had better body weight gain and feed conversion than INC and FLR birds by (Nissa *et al*., 2018). The improvement in the productive performance of broiler chickens exposedto LED lighting can be explained because of the calmness of the birds' behaviorand the decrease in response to stress, which leads to an improvement in the efficiency of food utilization and thus enhances feed conversion ratio and live body weight.

Table (1): Effects of lighting source on productive performance of broilers at 35 d of age.

Item	**Traits**				**SEM**	**P-value**
	INC	**FL**	**LEDW**	**LEDC**		
Live body weight (g)	2185^{ab}	2137^{b}	2192^{a}	2206^{a}	9.34	0.05
Body weight gain (g)	2143^{ab}	2095^{b}	2150^{a}	2164^{a}	9.35	0.05
Feed intake (g)	3522^{c}	3550^{a}	3527^{c}	3544^{b}	1.49	0.0001
Feed conversion ratio	1.644^{b}	1.694^{a}	1.641^{b}	1.637^{b}	0.01	0.01

a, b, ab and c Means within the same row with different letters are significantly different (P≤0.05).
NS = Non-Significant, SEM= Pooled standard error and P-value= Probability value

Carcass measurements:

In this experiment, the effect of light source on the carcass characteristics of broiler chickens was studied. Statistical analyses in (Table 2) showed that there was a difference between the experimental treatments in carcass weight, where the fourth group (LEDC) showed superiority in carcass weight

(2164g), while there were no statistically significant differences among the first (INC), third (LEDW) and second groups (CFL) which recorded the lowest carcass weight compared to the other three groups. While the light source did not affect carcass, breast muscles, leg muscle, edible parts, and inedible parts percentage. While there was a slightly non-significant improvement in the breast meat percentage in LEDC group compared to LEDW, INC and CFL groups (36.22, 35.42, 34.27 and 34.15 % respectively). These results are in great agreement with (Olanrewaju *et al.*, 2015), who reported an improvement in carcass weight in birds reared under cool LED differed from birds reared under INC. Some studies also indicate an improvement in the live weight and carcass weight of broiler chickens exposed to Cool-LED bulbs compared to chickens exposed to those of Warm-LED and INC bulbs by (Olenrawaju *et al.,* 2016). These results were in opposition to what (Santana *et al.*, 2014) found, where the weight of the live body and carcass weight was not affected by the light source (LED and fluorescent), while the results agreed that the carcass cuts were not affected by the light source. The slight improvement in breast tenderness may be due to LED light containing more blue/green light than incandescent lamps (Sultana *et al.,* 2013).

Table (2): Effects of lighting source on carcass measurements of broilers at 35 days of age.

Carcass dissection	Traits				SEM	Prob.
	INC	FL	LEDW	LEDC		
Live BW (g)	2183.67[b]	2132.33[c]	2192.67[b]	2207.33[a]	8.69	0.0001
Carcass wt. (g)	2139.17[b]	2085.94[c]	2149.35[ab]	2162.90[a]	9.09	0.0001
Carcass (%)	74.95	74.63	75.22	75.57	0.24	NS
Breast muscles (%)	34.27	34.15	35.42	36.22	0.36	NS
Leg Muscles (%)	33.63	32.67	29.21	29.17	0.92	NS
Edible parts (%)	79.07	78.18	79.95	80.67	0.48	NS
Inedible parts (%)	20.93	21.82	20.53	19.33	0.48	NS

a, b, ab and c Means within the same row with different letters are significantly different (P≤0.05).
NS = Non-Significant, SEM= Pooled standard error and P-value= Probability value

Blood parameters:

It is known that when exposed to stress, the level of plasma corticosterone increases in broiler chickens (Puvadolpirod and Thanton, 2000; Olanrewaju *et al.,* 2006). The corticosterone levels (µg/100 mL) of broilers at 5th week of age are shown in figure 1. Birds under CFL and Incandescent bulbs showed significant increases in corticosterone levels compared to LEDW and LEDC (603.00, 572.67, 519.33 and 517.00 for (CFL, IN, LEDW and LEDC respectively) which are indicative of stress. This result is in good agreement with the findings of (Archer, 2016), as found higher levels of plasma corticosterone in birds reared under incandescent light than the birds reared under the LED light. Also, (Nissa *et al*., 2018) noticed that the level of plasma corticosterone was significantly lower in birds under LED than those under natural light and Incandescent bulbs. According to (Huth and Archer, 2015), the corticosterone analysis showed that the CFL treatment had a higher value than the LED treatment. Whereas (Olenrawaju *et al*., 2016) did not find any significant difference in corticosterone level between birds raised incandescent, compact fluorescent and light emitting diode.

There is another measure of stress, which is the Heterophil/lymphocyte (H/L) ratio, which compares the ratio of two types of blood cells. When exposed to stress, the number of heterogeneous cells increases, and the number of lymphocytes in the blood decreases, as (Gross and Siegel, 1983) said. Our results showed that the H/L ratio in broilers raised under fluorescent lighting was significantly higher than in chickens raised under incandescent and LED lighting, which was as follows (0.45, 0.40, 0.40 and 0.38) for (CFL, INC, LEDW and LEDC respectively). And these results were the same results obtained by (Rogers *et al.,* 2015), where the H/L ratio was significantly higher in birds under fluorescent lamps compared to those under incandescent and LED lamps. And this agrees with (Huth and Archer, 2015) said in this regard, as H/L ratio was lower in LED treatment than fluorescent treatment. (Nissa *et al*., 2018) found high levels of H/L ratio in the birds reared under incandescent light than those reared under LED and natural light.

The lower levels of plasma corticosterone and H/L ratio in birds under LED compared to under fluorescent and incandescent can be explained because of the lower radiation from LED bulbs, which results in increased comfort levels and lower levels of aggression compared to fluorescent and incandescent bulbs that emit high radiation which caused stress in birds (Nissa *et al*., 2018).

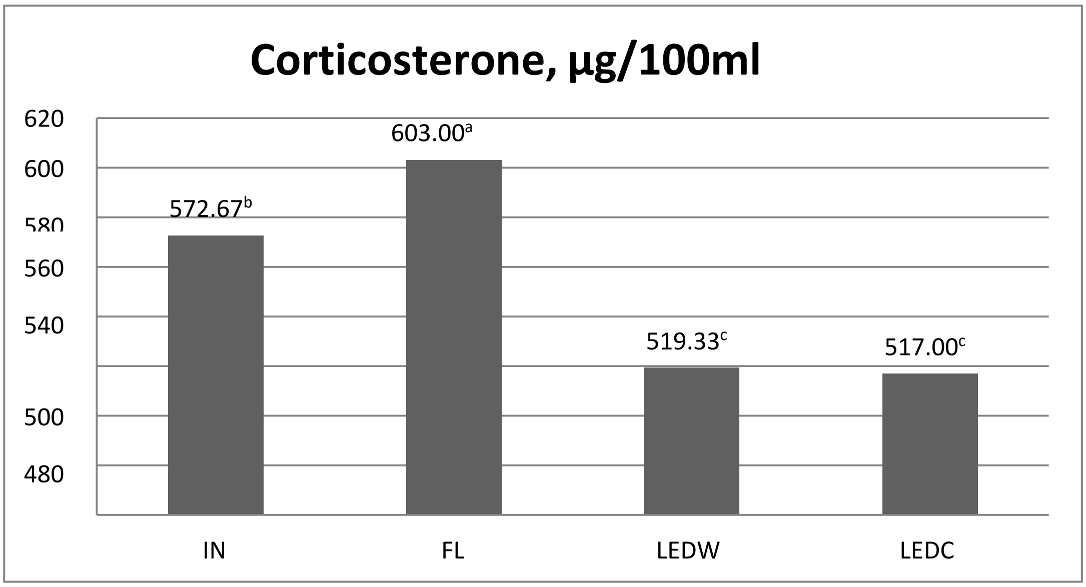

Figure (1): Mean corticosterone level of broiler chickens at 35 d of age

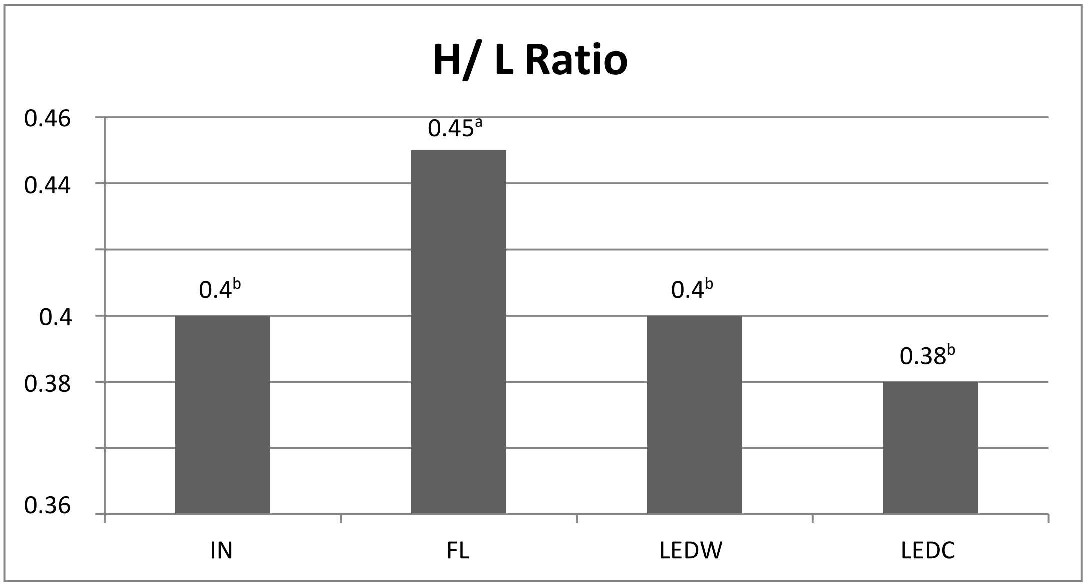

Figure (2): Mean heterophil to lymphocyte ratio of broiler chickens at 35 d of age

Kidney and liver functions affected by the source of light are shown in Tables No. (3). There were significant differences between groups in the level of creatinine in the blood, the FL group recorded the highest level of creatinine, while there were no significant differences between the INC and LEDW, while the LEDC recorded the lowest level of creatinine among the groups. While uric acid and liver enzymes (ALS and AST) had no significant differences between traits. These results are inconsistent with Firouzi *et al*. (2014), who noted that there were no significant differences in creatinine level in the blood of broiler chickens raised using green, sunny yellow, blue, and red light.

Table 3: Effect of lighting sources on kidney and liver functions of broilers at 35 days of age

Parameters	Traits				SEM	P-value
	INC	FL	LEDW	LEDC		
Kidney functions:						
Creatinine, mg/dl-1	0.33ab	0.36a	0.34ab	0.30b	0.01	0.01
Uric acid, mg/dl-1	5.26	5.95	5.83	5.34	0.21	NS
Liver functions:						
ALT, u/l-1	26.33	27.00	26.00	25.67	0.30	NS
AST, u/l-1	126.67	121.67	134.33	129.33	2.88	NS

a, b and c Means within the same row with different letters are significantly different (P≤0.05). NS = non-significant

The effects of lighting source on protein, lipid profiles and serum mineral levels are shown in Table (4). Date showed that total protein, albumen, and globulin were affected by the source of light. The fluorescent group had significantly higher total protein than other groups. As for the rest of groups, there were no significant differences between them in the total protein. In the same way, the fluorescent group recorded the highest albumin among the groups. As for the globulin, the LEDW group recorded the highest globulin, then FL, IN group, while the LEDC group had the lowest globulin between groups. According to the results, the source of light did not have effect on LDL. But there is an effect of the light source on HDL. Where the LEDC recorded the highest HDL when compared to the rest of the groups. As for total lipid, LEDW and FL recorded higher total lipid than LEDC and IN. The control group recorded the lowest blood cholesterol among groups. As for the triglycerides, the fluorescent group recorded the lowest triglycerides level in the blood. It noticed that treatment light bulbs didn't statistically affect the serum calcium and phosphorus levels on broilers.

These results are inconsistent with El-Faham *et al*. (2018), who demonstrated that, at 35 days of age, light sources had insignificant effect upon plasma cholesterol and triglycerides. Where the response to the light source on lipid metabolism showed the same trend as there were slight differences in cholesterol and triglyceride values (in plasma due to light sources (fluorescent vs. LED). Also, **Pan *et al*. (2014)** recorded that there were no effects of spectral composition on serum metabolic indicators including low-density high-density lipoprotein cholesterol (HDL-CH), total cholesterol (TC), total triglyceride (TG). Also, Firouzi *et al*. (2014) noticed that treatment light bulbs did not statistically influence the serum calcium, cholesterol, HDL and LDL levels when using green, sunny yellow, blue and red light.

Table (4): Effect of lighting sources on protein, lipid and plasma electrolytes of broilers at 35d of age

Parameters	Traits				SEM	P-value
	INC	FL	LEDW	LEDC		
Protein profile:						
Albumen, g/dl-1	3.63bc	4.23a	3.19c	3.72b	0.13	0.005
Globulin, g/dl-1	0.94c	1.16b	1.39a	0.88c	0.35	0.003
Total Protein, g/dl-1	4.57b	5.39a	4.58b	4.60b	0.11	0.0001
Lipid profile:						
Total Lipid, mg/dl-1	432.17b	515.27a	534.98a	450.76b	14.35	0.002
Cholesterol, mg/dl-1	182.74b	205.63a	212.59a	205.85a	4.00	0.01
Triglycerides, mg/dl-1	197.04ab	177.22b	183.88ab	204.19a	4.47	0.01
LDL, mg/dl-1	102.89	112.09	108.51	112.15	3.11	NS
HDL, mg/dl-1	54.03b	61.95ab	58.19ab	63.34a	1.52	0.01
Plasma electrolytes:						
Calcium	9.33	9.13	9.36	10.60	0.29	NS
Phosphorous	13.17	13.67	12.50	13.83	0.90	NS

a, b and c Means within the same row with different letters are significantly different (P≤0.05).
NS = non-significant, SEM= Pooled standard error and P-value= Probability value

As for thyroid hormones and growth hormone, the results in table No. (5) showed that there were no significant differences in the levels of thyroid hormones and growth hormone as a result of the different light sources. Similarly, Olanrewaju *et al*. (2016) noted that there were no significant effects on blood glucose and thyroid hormones levels of broiler chickens raised using different light sources (incandescent, compact fluorescent and light emitting diode lambs).

Table (5): Effect of lighting sources on growth related hormones of broilers at 35d of age

Parameters	Traits				SEM	P-value
	INC	FL	LEDW	LEDC		
T_3, ng/ml^{-1}	0.64	0.56	0.61	0.64	0.02	NS
T_4, ng/ml^{-1}	6.53	6.59	6.64	6.92	0.15	NS
Growth Hormone, ng/ml^{-1}	0.05	0.06	0.05	0.08	0.01	NS

[a, b and c] *Means within the same row with different letters are significantly different (P≤0.05).*
NS = non-significant, SEM= Pooled standard error and P-value= Probability value

CONCLUSION

Based on these results, LEDC technology proved to be the best alternative for INC and FL bulbs in broiler closed houses, as it improves FCR, carcass% and total breast muscle%. The LEDC bulbs achieved resistance to stress when recorded lowest values of blood corticosterone and H/L ratio. The best performance of kidney and liver functions was noticed in LEDC treatment. Regarding to thyroid activity, birds reared under FL bulbs showed the lowest T3 and T4 blood, while the LEDC had the highest values of GH in blood and highest values of blood Ca. Birds exposed to LEDW showed a high immune activity when increased in blood globulin, but it had the highest levels of total blood lipids and cholesterol. Therefore, we recommend using of LEDC bulbs instead of INC and FL bulbs in broiler houses.

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تأثير تكنولوجيا الإضاءة البديلة على الأداء الإنتاجي وخصائص الذبيحة وصفات الدم لدجاج اللحم

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تعتبر الإضاءة من العوامل البيئية الهامة للدواجن. أصبح من المهم الحصول على مصادر إضاءة بديلة لتجنب استخدام الإضاءة المتوهجة وتقليل تكاليف الإنتاج. هذه الدراسة تقوم بتقييم تأثير مصادر مختلفة من الإضاءة على الأداء الإنتاجي وخصائص الذبيحة ومقاييس الدم لدجاج التسمين. لهذا الغرض تم توزيع عدد 200 كتكوت تسمين من سلالة روس 308 على أربع مجموعات تجريبية كل منها يحتوي على 50 طائر. المجموعة الأولى للمقارنة حيث عرضت الطيور للإضاءة المتوهجة، والمجموعة الثانية عرضت الطيور للإضاءة الفلورسنت والثالثة عرضت الطيور للمبات الليد ذات لون أبيض دافئ والرابعة عرضت للمبات الليد ذات لون أبيض بارد. تم تسجيل الزيادة في الوزن والعلف المأكول ومعامل التحويل الغذائي. تم حساب وزن كلٍ من الذبيحة وعضلات الصدر والأرجل والأجزاء المأكولة والغير مأكولة من الذبيحة نسبة إلى وزن الطائر حى. تم قياس معدل خلايا الهتيروفيل إلى الخلايا الليمفاوية وتركيز هرمون الكورتيكوستيرون. تم ايضا تقدير البروتينات والليبيدات والكالسيوم والفوسفور وتم تقدير هرمون النمو في الدم. توضح النتائج الرئيسية أن استخدام لمبات الليد يمكن أن يزيد من وزن الجسم ويحسن معدل التحويل الغذائي، ولكن لا يوجد فروق معنوية بين المعاملات بالنسبة لخصائص الذبيحة. بالإضافة إلى أن استخدام اللمبات الليد قلل من معدل خلايا الهتروفيل إلى الخلايا الليمفاوية وقلل من مستوى الكورتيكوستيرون بالدم، مما يشير إلى تقليل الاجهاد الواقع على الطيور. مضمون هذه الدراسة يشير لأفضلية استخدام تكنولوجيا الإضاءة الليد الباردة بدلاً من الفلورسنت أو اللمبات المتوهجة في مساكن دجاج اللحم، حيث حققت تحسن في معامل التحويل الغذائي ونسبة الذبيحة وعضلات الصدر الي الوزن الحي مقارنة ببقية المعاملات. وكذلك أثبتت مقاومة أفضل للإجهاد من خلال انخفاض مستويات الكورتيكوستيرون ونسبة خلايا الهيتيروفيل الي خلايا الليمفوسيت في الدم. وكان لهذا النوع من اللمبات تأثير جيد علي وظائف الكبد والكلي في الدم وكذلك المستوي المرتفع من هرمون النمو مقارنة ببقية المعاملات.